Instruments

E MAGAZINE of MEASUREMENT and CONTROL

Vol. 21 SEPTEMBER 1948 No. 9

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One MULTIPLE POINT CELECTRAY

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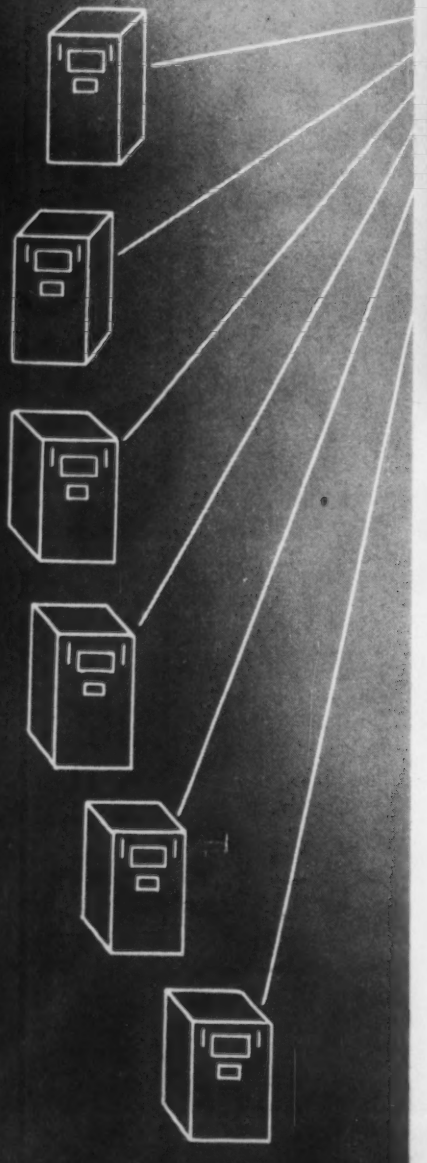

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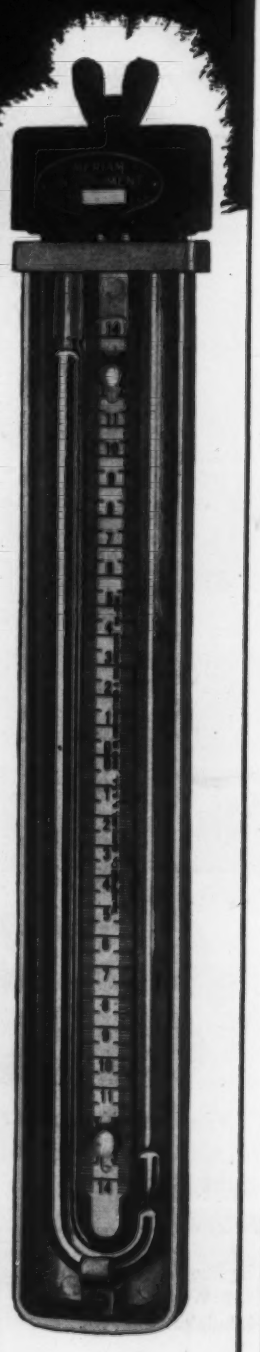

Measuring directly in inches or millimeters of mercury

This new instrument is proving notably popular in various industries for the measurement of *absolute pressures* from one millimeter of mercury to the equivalent atmospheric pressure.

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Of simple design—no cams, gears, levers—the Meriam U-Type Absolute Pressure Gauge is accurate and dependable. It is strongly built for lasting service. The gauge head fastens to the body by a single wing nut. Available in wall or flush front mounting styles. The wall mounted unit, illustrated, is Model C-1142 WM and is fully described in catalog sheet C-1142 WM—available upon request.

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Instruments

Vol. 21 SEPTEMBER 1948 No. 9

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C. Zatkovich, *Assistant to the Editor* (new literature, layouts, etc.)

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

TWO weeks from the time of writing these lines, the third National Instrument Conference and Exhibit will open its doors in Philadelphia. As on preceding occasions, we have been asked to "open" it on paper.

Since *Instruments*' publication date is the 15th, and since the Conference will be held from the 13th to the 17th, our subscribers will be reading this page the week after they may have read about the Conference in their daily newspapers. This year there OUGHT to be more newspaper publicity than in 1946 or 1947, because both the Conference and the Exhibit are bigger, more varied and more newsworthy. (See the programs in last month's *Instruments*.) But there may be less newspaper publicity. Here is why:

In December 1946 the ISA selected the place—Philadelphia—and the time—Sept. 13-17, 1948—and promptly announced this decision to all organizations concerned. Months later, the American Association for the Advancement of Science, planning its Centennial Celebration for the autumn of 1948, found that the only suitable place was Washington and the only suitable time, the week of September 13th! Therefore, as you read this page you probably will remember having read many scientific and technical news items datelined Washington . . . and only a few brief ones datelined Philadelphia.

Detailed reports of the ISA Conference and Exhibit will appear in the October *Instruments*—both in the ISA Journal section and in "the front of the mag." Although specific details cannot be foretold, a broad over-all picture can be foreseen. It is a picture of continued advances on most fronts. Thus, predictions made two years ago may be repeated—predictions of greater importance of the functions assigned to (A) instruments and (B) Instrument Men.

(A)

The increasingly-important functions assigned to measuring and automatic-control instruments will be:

1. Minimizing the sum total of human drudgery, especially in eliminating repetitive operations and particularly in automatic dimensional gaging, automatic inspection of products, automatic grading, etc.;
2. Creating new and better kinds of jobs;
3. Bettering working conditions;
4. Labor saving in the sense of increasing productivity bringing about higher wages and lower prices;
5. Fuel saving and electric-energy saving in utilization;
6. Materials saving;
7. Prolonging the service-life of processing equipment;
8. Increasing production from processing equipment;
9. Accelerated modification of processing equipment, even to scrapping present equipment in acceptance of the oft-repeated preachment "Design controllability into production units!";
10. Better quality and uniformity of product;
11. Minimization (sometimes elimination) of rejects;
12. Minimizing reliance on human watchfulness;
13. Accident prevention;
14. Accelerating the conversion of batch processes to continuous processes;
15. Closer control in both senses: (a) product control and (b) automatic control;
16. Improvements in services rendered to the public by ALL of the competing transportation industries;
17. Ditto for the communications industries;
18. Continued improvements in meteorology, navigation, geophysical sciences, biological sciences, preventive and curative medical practices . . . and numerous other non-industrial fields depending increasingly on instruments;
19. Creating new industries and rehabilitating and expanding old industries.

(B)

There will likewise be an enhancement of the functions assigned to the Instrument Man, be his title "mechanic" or "President." The enhanced importance of these functions will be accompanied by:

1. Enhanced status—increased recognition by others and increased pride in one's own job regardless of title.
2. Greater stability of employment—less dependence on "politics" or on the fortunes of wars between factions.
3. Relatively higher percentual raises in pay.
4. Closer association of Instrument Men with one another through formation of new ISA Local Sections.
5. Closer association of instrument-minded engineers, technicians, scientists, executives, educators, etc., with one another through greater official interest in Measurement and Control within other existing societies.
6. An increase in instrument education—first a QUANTITATIVE increased enrollment in courses on Instrumentation subjects.
7. A corresponding—but not measurable—QUALITATIVE improvement in instrument education. —MFB

THIS MONTH WE CONGRATULATE

E. A. Uehling
Instrumentician,
manufacturer
and inventor

The American
Association for
the Advancement
of Science

BOTH ONE HUNDRED YEARS YOUNG

The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 867

Displacement-input Remote-reading-and-control System

New "Atcotran Precision Measuring System" is an industrial electric-gaging system of the variable mutual-inductance type (phase-responsive sub-type) with a choice of primary elements to actuate the standardized transmitting units and choice of instruments and automatic-control auxiliaries. Thus, possible combinations of already-available elements run into the thousands. (Therefore, none of the photographs accompanying the announcement are used.) Common feature of all systems is "Atcotran" pick-up (Fig. 1) which has well-known advantages of three-winding inductance-type displacement pick-up and is said to have a unique combination of advantages resulting from five years of research and development preceding first public announcement. Intrinsic sensitivity and accuracy of "Atcotran" are such that in many cases the over-all sensitivity (with primary element) is 0.025% and over-all accuracy 0.25%. Distance from pick-up to instrument may be 1000 ft. without special provisions. "Atcotran" does not require special high-frequency power supply because primary-winding excitation is from ordinary 60-cycle source. It can operate under water. It imposes "little or no reaction force" on primary measuring element and, in most applications, requires 3 volts per unit from 60-cycle source. Fig. 2 shows typical characteristics: linear response, 0.05" total displacement for varying output from zero to full value, and 0.1 volt maximum output. Two or more "Atcotrans" may be connected to give an electrical output which is the sum, difference or average of a plurality of primary-element displacements and hence of related variables. Simplest system (not illustrated) consists of an "Atcotran" with bucking-connected secondaries and a 0.1-volt a-c. voltmeter. Usual method of application of "Atcotran" is in vertical position for completely eliminating friction, as shown in Figs. 3 and 4. These diagrams show two of the numerous circuit possibilities and industrial-application possibilities. Fig. 3 shows a variable-inductance telemetering or remote-control circuit with automatic self-balancing; Fig. 4 shows a simple on-off control circuit and suggests also the three-position circuit employing two electronic relays, one on "A" phase and one on "B" phase.—*Automatic Temperature Control Co., 5212 Pulaski Ave., Philadelphia 44, Pa.*

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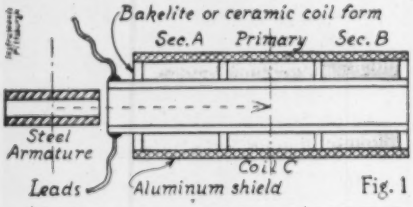


Fig. 1

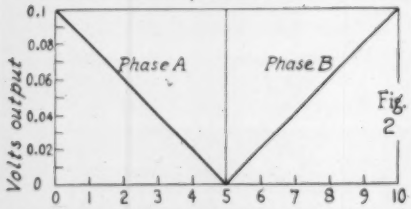


Fig. 2

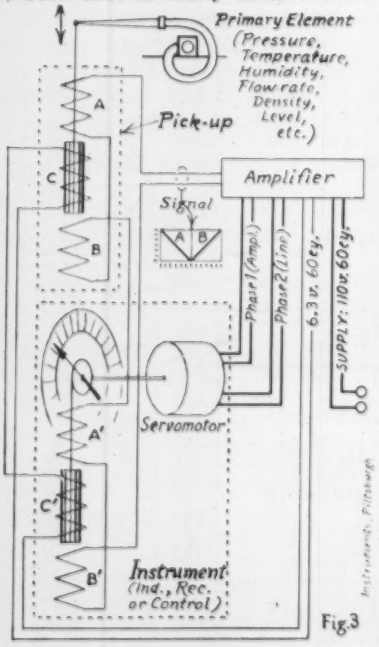


Fig. 3

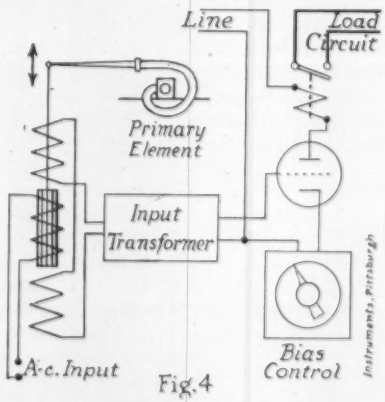


Fig. 4

Pressure-telemetering System

New "Atcotran" pressure-measuring and transmitting system, said to have been under active development for the past five years, employs "Atcotran" mutual-inductance pick-up (described in preceding item) actuated by standard primary measuring elements such as Bourdon tubes or bellows (depending upon pressure range), so as to eliminate or minimize problems of zero checking, inability to load to full rated range, hysteresis effects, etc. Bourdon tube is not called upon to accomplish any work: only the "Atcotran" armature moves slightly. Zero adjustment is embodied in a simple thumb-screw, standard on all units. It is claimed that Bourdon tubes may be loaded to full rated range and consistently return to "zero" position within accuracy limitations of "Atcotran" system. New transmitters and standard "Atcotran" receivers (indicators, recorders, etc.) are accurate to within 0.25%. Sensitivity of 1 part in 4000 or better is said to be usual performance. Any number of pressure transmitters, of either the same or different ranges, may be read from one common indicator equipped with selector switch stations. Transmitters consisting of K-Monel Bourdon tubes mounted in dust-tight enclosures are suitable for service on many corrosive applications such as H_2S-bearing gas and oil, oxygen NH_3, fluorides, hydrochloric acid, brine and caustic soda. Standard ranges: 0-30/100/500-/1000/5000/10,000 lbs./in.^{2}. —*Automatic Temperature Control Co., Inc., 5212 Pulaski Ave., Philadelphia 44, Pa.*

Please mention number 902 when filling out card

High-output Resistance-thermometer Bulb

New 400-ohm resistance thermometer bulb has been developed to satisfy demand for a high-output primary element. New design has an ice-point resistance of 400 ohms. In spite of this high resistance, bulb is only slightly larger than maker's other types. Diameter is 0.200"; wound length 2". Bulb is made only in "Type B" and "T," that is, tungsten wire embedded either in quartz or Pyrex glass. New bulb offers an eight-fold increase in sensitivity over a 50-ohm bulb.—*Paul G. Weiller, 95 Broad St., New York 4, N. Y.*

Please mention number 903 when filling out card

Flow-rate-meter Primary Element

New "Beth-Flo Gentile (pronounced en-tilly) Flow Tube" is said to represent not only the first major improvement in head-meter primary elements in fifty-seven years "but a definite change in the principles of flow metering." It consists essentially of a short length pipe equipped with two groups of pressure nozzles around the inner

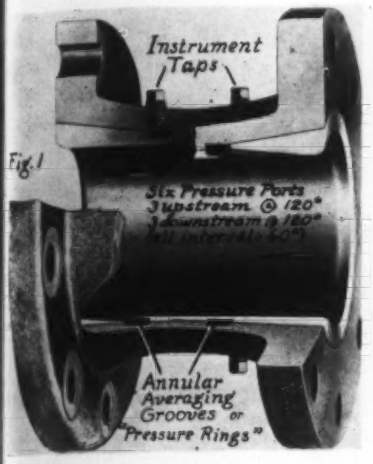


Fig. 1

periphery — one group pointing upstream, the other downstream. Each nozzle group is interconnected by a common pressure ring. From these two pressure rings, connections are made to the high- and low-pressure sides of flowmeter. Differential head is difference between total head impressed on nozzles pointing downstream and total head impressed on nozzles pointing upstream. Symmetry of new device permits measurement of flow in either direction. Flow tube is normally less than one pipe diameter in length; can be installed at any section of a pipe-line with no straight run limitations; offers a negligible resistance to flow and thereby saves power; obviates need of expensive masonry vaults required for many long-tube primary elements; provides a differential greater than that of a Venturi or orifice for same ratio of flow tube to pipe diameter, so that range for measuring light gases or slow-moving liquids is increased. Accuracy is constant over entire range of commercial flow measurement. New flow tubes can meter gases and vapors as easily as liquids. All readings being taken at the same section of flow path, usual corrections for internal energy changes drop out of the flow formula. Accuracy is not affected by assumptions inherent in readings of other types of primary elements. Discharge coefficient is, simply, $CA\ (2gh)^{\frac{1}{2}}$ for all values of P_2/P_1 and no corrections are necessary when downstream pressure falls below critical value, i.e., 52% for air, 57% for steam, etc. Several designs and sizes are already available. Fig. 1 shows a [illegible]" inlet-diameter "Type V" tube with [illegible]" flange OD and 6" flange face-to-face distance or tube length. Fig. 2 is two small portions of a page-size drawing of the 24" inlet-dia. "Type D" tube with 31" flange OD and 16" tube length. Structurally, this type consists of a simple casting with throat machined and highly finished, into which are positioned six nozzle pieces (Fig. 2B) connected to two pressure-rings (No. 6 in Fig. 2A) which are external hoops of tubing encircling the casting. Tests and calibrations were made at Alden

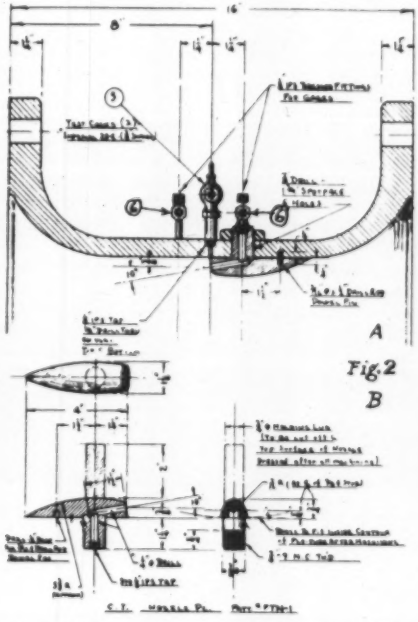


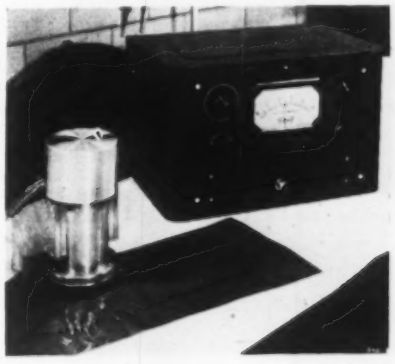
Fig. 2

Hydraulic Lab. of Worcester Poly. Inst.; and report contains statement that new tubes "can do as good or better than a Venturi in all cases. . . . accurate commercial range is greater than that which could be reached with test apparatus."—*Bethlehem Foundry & Machine Co., Bethlehem, Penna.*

Please mention number 904 when filling out card

Radioactive Thickness Gage

New radioactive thickness gage uses carbon 14 as a source of radiation. This isotope has a half-life of about 5100 years, thus provides constant-intensity source. Radiation, consisting of beta particles of low penetrating power, is well suited for gaging thin films. Plastic film such as Pliofilm or vinyl film may be gaged to a maximum thickness of about 0.005" with an accuracy of 1%.



There is no shielding problem with this low penetrating type of radiation. Film thickness is determined by measuring film's absorption of radiation, by passing film through a slot between source and an ionization chamber. Ionization current produced by beta rays which have passed through film is amplified by subminiature vacuum tubes. No mechanical contact with the film being required, continuous gaging is possible. —*Goodyear Tire and Rubber Co., Akron, Ohio.*

Please mention number 905 when filling out card

Air-operated Flow-rate Controllers

New pneumatic control mechanism is incorporated into maker's flow controlling instruments. Housing for this new unit is a one-piece die casting to fix all component parts. All important working parts are made from precision castings or heavy stampings, precision trimmed and completely interchangeable. Entire assembly may be removed from control instrument without disturbing controlled process, by flicking transfer valve to "Service" position, disconnecting a single air line and removing four screws. A minimum of tubing connections is claimed to eliminate air-leakage troubles. Alignment of pen and index is assured throughout range since both index and input links swing on a common center. Valve action is easily reversible without altering link relationships. Pen tracks set point throughout 0-to-200% throttling range adjustment. Reset is calibrated from 0.2 to 50 minutes and this is claimed to "guarantee on-the-beam results the moment the controller goes on stream." —*Fischer & Porter Co., Dep't 5C-N, Hatboro, Pa.*

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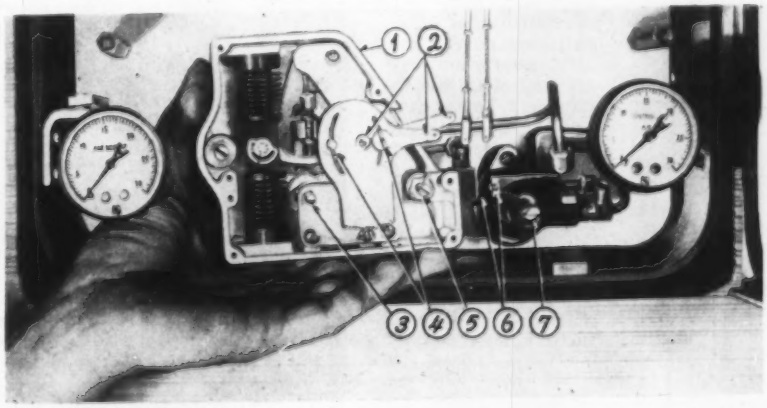

(1) Single-piece die-cast housing. (2) Concentric input and index action maintains fixed relationship throughout entire range. (3) Control point is not disturbed when valve action is reversed. (4) Control assembly easily removed without shutting down system. (5) Reset speed adjustment calibrated 0.2 to 50 minutes. (6) Automatic-Service-Manual transfer valve. (7) 0 to 200% throttling range adjustment.

Smoke Density Recorder

New Smoke Density Recorder consists of maker's standard "Electronic Recorder," a bolometer-type smoke detector and a sealed-beam source of radiant energy. Bolometer principle used is the same as used by astronomers for measuring radiation from stars. Amount of radiation reaching tungsten filament of bolometer depends upon density of smoke or dust; and temperature of the filament depends upon amount of radiation reaching it. Filament temperature is measured by "Electronic Recorder" in terms of smoke density. To insure alignment of bolometer and light source, they are mounted at ends of a 4" pipe extending across flue; pipe is slotted for free passage of smoke into radiant-flux beam. A temperature-compensating circuit prevents ambient-temperature errors and is unaffected by normal voltage variations. Bolometer is of "sealed-beam" construction (similar to automobile headlamp) to resist corrosive vapors. System uses null method of measurement: voltage drop across the bolometer filament automatically balanced against voltage drop across a motor-driven slidewire unit in recorder. Two Smoke Detectors may be connected to a two-pen recorder; or a record of smoke density may share same chart with one of temperature, percent oxygen, etc. Each measuring circuit may be equipped with switches to actuate high-smoke-density signals or alarms; or with control to automatically turn on over-fire jets.—*Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.*

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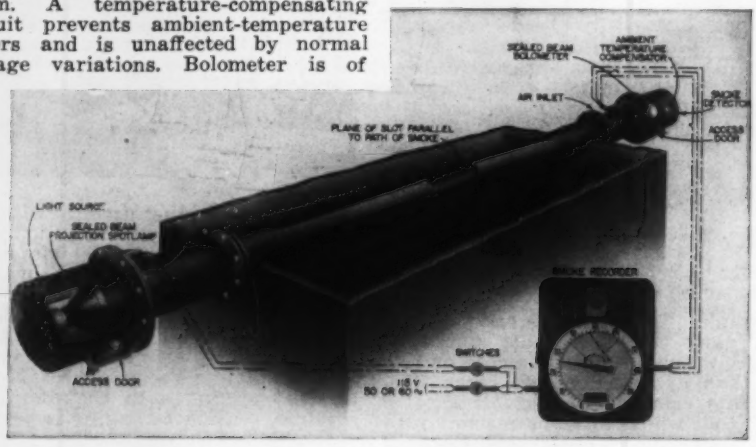
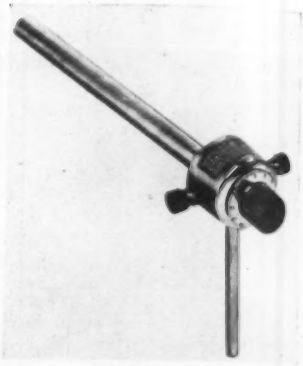


Thermoregulator

New thermoregulator is modificati of maker's "Sciaco" thermostat wi special emphasis on its use as a labor tory instrument. Unit has 9" 18-8 stai less steel sensitive element and utiliz differential expansion betwe outer shell and inside element. Outer she

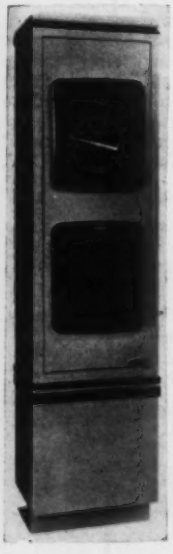


being directly responsive, high sensiti ity is claimed (±0.03°C.) Unit ha graduated dial and neon pilot light indicate control point, all contain in a case of spun nickel-silver. Tw non-removable binding posts connect i ternally to contacts by means of silico insulated lead wires. Capacity, 5 watts, 115 volts a.c., temperatu range, room to 200°C.—*Smith Contr & Instrument Co., 1329 Highland Ave Needham 92, Mass.*

Please mention number 909 when filling out card

Air-conditioning Control Cabinets

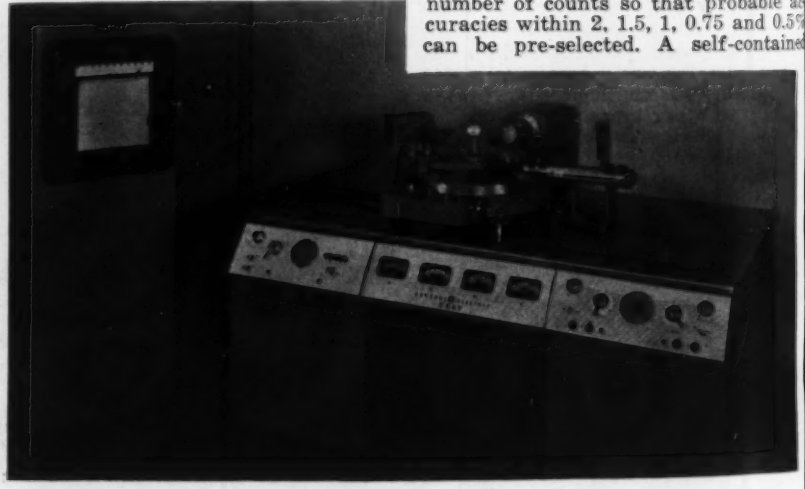
Two new "packaged unit" instrument cabinets for air-conditioning systems are adaptable to various industrial or commercial requirements. In appearance they are almost identical. Each has a "Dynalog" temperature indicator, above a key-switch panel to connect indicator with numerous resistance bulb circuits. But while one unit measures only dry-bulb temperatures, the other will measure both temperature and dew point. Indicating instrument has a dual range, outer scale for dry-bulb temperature and inner scale for dew-point temperature. Unit is 80" high, 20" wide and 15" deep. Steel doors at back give access to wiring, all of which is done at factory, so that only external connections are necessary when cabinet is installed. Other sections to match may be combined, making an instrument board of any desired dimensions.—*The Foxboro Co., Foxboro, Mass.*



Please mention number 908 when filling out card

X-ray-diffraction-method Chemical Analyzer

New high-precision, high-output x-ray diffraction machine aids identification and quantitative analysis of unknown materials. One attachment, fluorescent analyzer, greatly extends range of composition of materials which can be analyzed, in comparison with that possible when using optical spectrometers. Another group of attachments makes possible direct recording of x-ray intensities on a continuous strip chart, saves laboratory time by revealing both angular placement of characteristic lines of materials and their relative intensities. New unit couples for the first time, it is said, precision control of x-ray output wi high x-ray intensity. X-ray intensit of unit is controllable and reproducib to 0.5% by controlling x-ray tube vol age to within 0.1% and tube curre to within 0.02%. Thus, both resolutio of lines and speed of analysis a greatly increased. High output achieved through use of a new sealed off diffraction tube with three pur beryllium windows within 1" of en and focal spot of tube. Focal spot si and distribution also contribute t output. The Spectrogoniometer read angles directly down to 0.01°. X-ra quanta count scaler is used to measur time required to produce a pre-selecte number of counts so that probable ac curacies within 2, 1.5, 1, 0.75 and 0.5% can be pre-selected. A self-containe



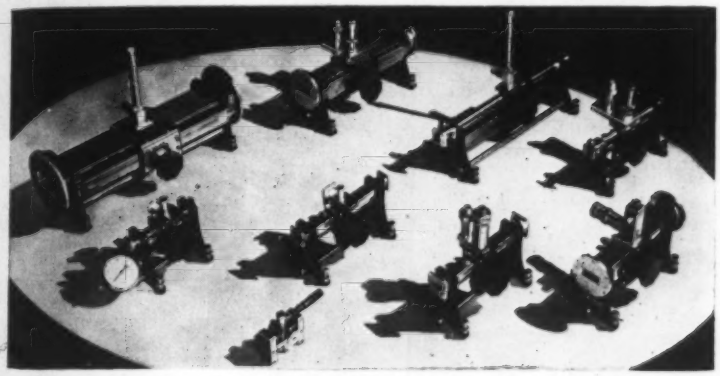
x-ray tube cooling system eliminates plumbing and operational difficulties associated with conventional tap-water systems. Sample holders are provided for reflection and transmission techniques; also a sample spinner for fractional gram quantities of material and an integrating flat sample spinner for medium grain size samples. Diffracted-beam monochromator provides for optimum contrast of diffracted intensity over background.—*General Electric X-ray Corp., 175 W. Jackson Blvd., Chicago 4, Ill.*

Please mention number 910 when filling out card

Precision Impedance Meters

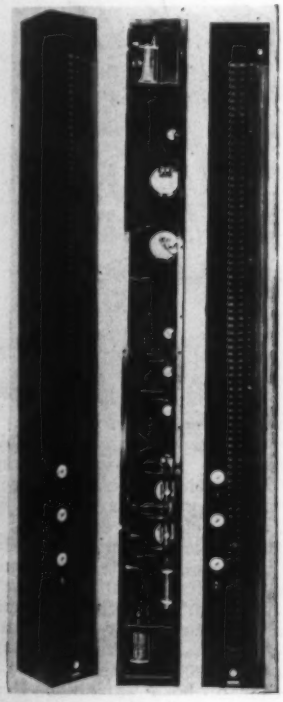
New complete series of nine precision impedance meters determine impedance by measuring standing wave ratios and node positions in microwave transmission lines. They can also measure relative power, attenuation, and wavelength in the line. Series covers all standard sizes of waveguide from 3″ × 1½″ to 0.360″ × 0.220″ and rigid coaxial lines of ⅝″ and ⅞″. Accuracy and repeatability of measurements is 2%. Probe position can be measured to 0.1 mm. on vernier scale instruments and to 0.01 mm. on dial and micrometer instruments.—*Industrial Dept., Sperry Gyroscope Co., Great Neck, N. Y.*

Please mention number 911 when filling out card



Multi-range Manometer

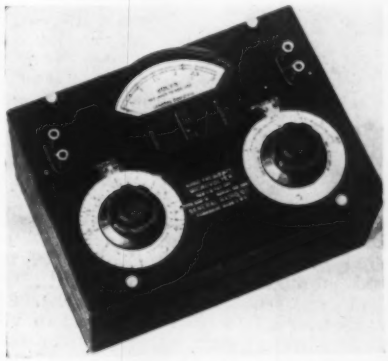
New 240″ multi-range mercury manometer is a direct-reading instrument with scale graduated and calibrated for three ranges of pressures. Instrument operates automatically by means of compressed air; is enclosed in compact steel frame to conserve floor space; provides for over-travel of indicating fluid at both top and bottom with full utilization of scale without danger of fluid loss. Scale is adjustable (more than 1″) for zero level correction. Manometer well has sufficient capacity to permit full indications without danger of blowing through fluid. Design is claimed to prevent entrainment of liquid through top of well. Fluid can be drained without dismantling. Precision glass manometer tubing has inside bore of about 0.312″ (exact dimension stated on nameplate) and outside diameter of 0.450″. Manometer has single scale calibrated in inches and tenths of inches. 1″ and 0.5″ divisions are provided with three sets of graduations: 0-80″, 80-160″ and 160-240″. Length of manometer permits use over entire range without danger of blowing indicating fluid. Once operating pressure has been standardized, instrument is said to reproduce specific pressures over long periods of use. As pressure increases from 0 to upper scale range of about 80″, indicating fluid is automatically suppressed to 0 position and, simultaneously, electric illumination on 0-80 scale is extinguished and illumination is turned on for the 80-160 scale. Similarly, the fluid is suppressed and lights changed automatically for the 160-240 scale; also in reverse order. Air control system supplied is "Nullmatic" type with filters, control valves, etc. Accuracy of 0.1% at any scale reading is claimed and all parts are interchangeable. Furnished with 10-ft. cord and plug for 110-volt a.c. Air pressure supply is 100-lb. gage—*George K. Porter, Hatboro, Pa.*



Please mention number 912 when filling out card

Audio-frequency Microvolter

New "Type 546-C" audio-frequency microvolter has been redesigned to improve sensitivity, frequency response and distortion characteristics, and to standardize its impedance level at 600 ohms. Consists essentially of a sensitive voltmeter and a precise attenuator. Converts any audio oscillator to a standard-signal generator, capable of such measurements as gain or loss, frequency response, overload level and hum level on amplifiers, lines, and other networks. Output voltage range is 0.1 microvolt to 1.0 volt, open circuit for an input of 2.2 volts across 600 ohms. Accuracy is ± (3%+0.5μv.) for output levels above 1μv. at frequencies below 20,000 cycles. At frequencies up to 100,000 cycles, accuracy is ±5%. Ratios at a single frequency are accurate to ± (2%+0.5μv.). Distortion introduced by microvolter is about 0.2%. Over-all dimensions 10″ × 7″ × 6⅜″; weight 6½ lbs.—*General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*



Please mention number 913 when filling out card

Pressure Pick-up

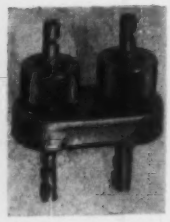
New "Type 5" element replaces maker's "Type 3" pressure element and "Type 3" gas sampling valve. It can be used with maker's direct pressure engine indicators and gas sampling units. "Type 5" is 40% lighter and has much greater area of opening and smaller internal volume. It will permit taking an indicator card for a complete cycle in 1/3 to 1/5 time required with former type. It is made with poppet-type valve which opens outwardly, or toward compression or combustion chamber. Spring pressure alone is no longer depended upon for sealing when valve is shut. Valve lift can be adjusted without disassembly. "Type 5" element requires no cooling in normal engine installations. Engine indicator has a linear calibrator un-

affected by temperature of element. Weight, 2 lbs.; overall length, 7½"; body diameter, 2¼"; shank length—overall, 3⅝", working length, 2⅝".—*Commercial Research Laboratories, Inc., 20 Bartlett Ave., Detroit 3, Mich.*

Please mention number 914 when filling out card

Electrical Connector

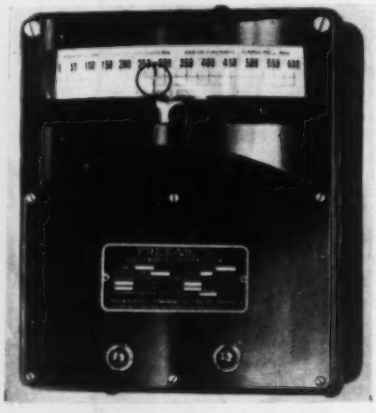
New "Series 500 Connector" is a through-firewall connector used for thermocouple or other electrical connections; has been developed to enable compliance with C.A.A. Fire Prevention Requirements. It has a Steatite insulating body with stainless steel bushings, jack-heads and coupling nuts. To add physical strength, Steatite body is enclosed in a stainless steel jacket. Body is 2" × 1" × 7/16" and is mounted on firewall with two 6-32 screws. Assembly weighs 3¼ ounces, and has been subjected to vibration and temperature tests up to 2300°F. without failure.—*The Winslow Company, Inc., 9 Liberty St., Newark 5, N. J.*



Please mention number 915 when filling out card

Proportioning Pyrometer Controller

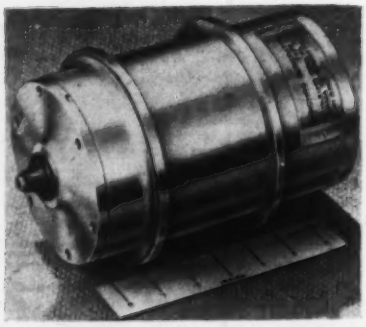
New "Model IE486" proportional current-input electronic pyrometer controller proportions the current input to electrically - heated furnaces, ovens, plastic molding machines, salt pots, etc., is said to provide practically straight-line temperature control by time modulation of input energy. Average energy supplied is proportional to deviation of temperature from control point, throughout a band width adjustable from 0 to 2½% of full-scale reading.—*The Bristol Co., Waterbury 91, Conn.*



Please mention number 916 when filling out card

Synchro Units

New line of Synchro Units designed specifically for electronic, electromechanical, and electrohydraulic control systems; and for remote-control and indicating purposes; includes control transformers, motors, generators, differential motors and differential

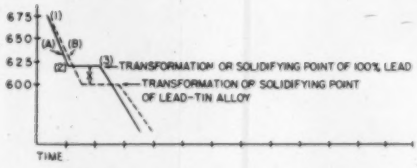


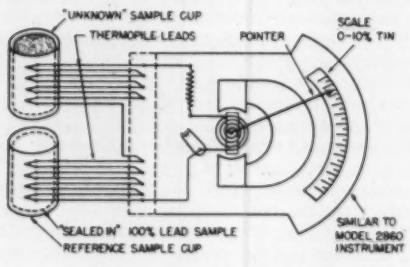
generators. All were originally developed as parts of Navy instruments and are high-precision devices. None is designed for direct transmission of power or torque.—*Arma Corp., 254 36th St., Brooklyn 32, N. Y.*

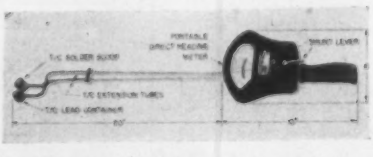
Please mention number 917 when filling out card

Solder Tin Content Indicator

Now "Model 2870" portable solder tin content indicator, for quick analysis of solder quality, determines ratio of lead and tin content in solder; is direct-reading, was developed in coöperation with Continental Can Co.; consists essentially of a high-resistance pyrometer and dual thermocouple extensions: one with a Lead Container, the other one with a Solder Scoop. Instrument movement contains baked process coils, is enclosed in a dust-proof aluminum housing. A shunt lever protects movement when instrument is not in use. Adjustable pistol-grip handle may be locked in horizontal or vertical position. A 3-9/16"-wide mirrored scale is calibrated in divisions representing percentage of tin content. Steel sensing unit consists of two rigid tubes with sample cups mounted on ends. Method of obtaining the tin content percentage is based on the difference in temperature between a pure lead standard and a lead-tin alloy sample, while these materials are passing from liquid to solid consistency: pure lead sample is permanently sealed in one cup while solder sample to be tested is scooped into other cup and retained there until reading is obtained. Indicator weighs 4½ lbs.—*Wheelco Instrument Co. 847 W. Harrison St., Chicago, Ill.*







Please mention number 918 when filling out card

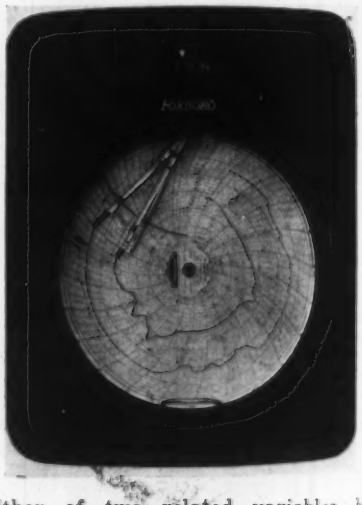
Apparatus Connector

New hook connector can quickly be attached to or removed from maker's "Flexaframe" supports without disturbing other units of the frame. Especially useful for connecting "Flexaframe" or other ½" rods at right angles and as a clamp holder, new connector is made of non-corrosive "Castaloy."—*Fisher Scientific Co., 711 Forbes St., Pittsburgh 19, Pa.*

Please mention number 919 when filling out card

Two-variable Automatic-selecting-type Controller

New "Auto-selector Controller" is said to be "an important addition" to maker's line of industrial control instruments. It controls, selectively, from either of two related variables, its positioning a single valve, damper, or other final element. This selection is determined by the variable having the greater tendency to exceed its pre-set limit; transfer of control is said to be made smoothly, instantly, and automatically. New "Auto-selector" that does the work which previously required two controllers; has an added advantage in that it may incorporate automatic-reset function in the control of either or both variables. Design of instrument embodies two measuring systems and two inter-connected "Model 40" control mechanisms. Control action of both mechanisms may be on-off, proportional, proportional with derivative, proportional with reset ("Stabilog"



D-175730
Primary Frequency Standard

Here is a 100 kc frequency source of the highest precision—yet rugged enough to be used in semi-portable service.

The frequency of the Western Electric Primary Frequency Standard D-175730 is maintained to within one part in 10^8, measured over a period of one day, regardless of moderate changes in ambient temperature, humidity and air pressure.

Heart of this high-precision instrument is a GT-cut crystal, suspended by wires inside an evacuated glass envelope. Crystal is cut and ground for extremely low temperature coefficient (less than 10.5 parts per 10^8 per degree F) and is enclosed in an oven that maintains constant crystal temperature within 1/100 of a degree.

If you are making time-frequency measurements —or operating two or more independent systems in synchronism – you will want to investigate the Western Electric Primary Frequency Standard. For further information, call your nearest Graybar Representative, or write Graybar Electric Company, 420 Lexington Avenue, New York 17, N. Y.

Western Electric

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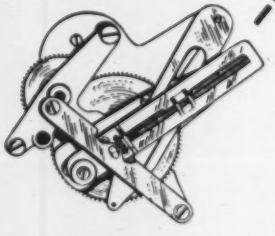
Servograph

POSITION RECORDER

A new type graphic recorder which operates from a remote point WITH NO MECHANICAL LINKAGE.

the heart of the servograph----?



is an extremely accurate variable ratio device making the SERVOGRAPH so flexible that a single adjustment provides full chart coverage within a range of ½ to 15 revolutions.

"Records almost anything that moves"

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SERVO-TEK PRODUCTS CO.

INCORPORATED

Manufacturing Division

4 Godwin Avenue · Paterson 1, N. J.

proportional with reset and derivative ("Hyper-reset") or any combination of these. Among applications: (1) in pipeline pumping station to control either discharge pressure or suction pressure of pump in accordance with supply and demand requirements; (2) control of brine flow through a heat-exchanger to maintain temperature of cooled material at a pre-set value as long as outlet brine temperature is above a pre-set minimum; (3) control of fuel supply to operate an oven at a desired temperature while keeping heater temperature below a safe limit. It is not necessary that the controlling measurements be of like variables. Any two that are related may be combined. "Auto-selector Controller" is available as a recorder or indicator.—*Foxboro Co., 46 Neponset Ave., Foxboro, Mass.*

Please mention number 920 when filling out card

Industrial Counter

New "Type 82-A" single control register is a double counter. Upper set of figures (⅞" high) records a count of up to 999, while lower set of figures (9/16" high) gives a grand total accumulative up to 99,999. Register is operated by a lever at right which may be moved by hand or actuated by any reciprocating-motion member.—*Ohmer Corp., Box 998, Dayton, Ohio.*

Please mention number 921 when filling out card

Molded Transformer Cores

New horizontal deflection and flyback transformer cores molded from iron powders for television applications are said to assure uniform operating results while permitting easier assembly at a worthwhile cost saving. "Type 10034," a large rectangular unit with sliding hub, is designed for universal use with any television tube where magnetic deflection is used. A smaller "spool" type, "No. 10748," is recommended where space is at a premium and where tubes are no larger than 10". —*Electronic Components Div., Stackpole Carbon Company, St. Marys, Pa.*

Please mention number 922 when filling out card

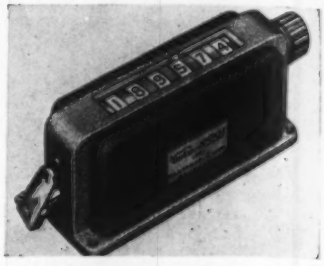
Photoelectric Relays

New "Type ES-1" low-cost photorelay operates from 115 volt, 60 cycle a.c., comprises a phototube, amplifier, relay, sensitivity adjustment, all mounted on a 2½" × 5" steel chassis. Built-in outlet delivers 115 volt 60 cycle when light entering 1" opening to phototube is intercepted. Any kind of lamp or daylight will operate it. Response time is about 1/20th second. "Type ES-2" is similar, but includes a light projector built into base of chassis, projecting a narrow beam of light outward to a mirror which then reflects this light back into phototube opening above projector lens. — *Photobell Co., 116 Nassau St., New York 7, N. Y.*

Please mention number 923 when filling out card

General-purpose Counters

New "Series 1259, 1260, 1261 and 1262" general-purpose counters are 4½" × 1-9/16" × 1¼" high; have a

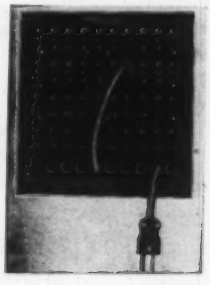


6-digit cyclometer, do not require lubrication. Rachet type, 32° to operate, 60° max., 1000 counts per minute maximum speed. Rotary ratchet type, 45° to operate, will accept up to 20° overtravel each end of stroke, 1500 cpm. max. Revolution type, 2000 cpm. max. Direct-drive type, 5000 cpm. max. Reset is standard on all types. Right or left shafts. Shipping weight, 12 oz.—*Veeder-Root, Hartford 2, Conn.*

Please mention number 924 when filling out card

Thermocouple Connector Panels

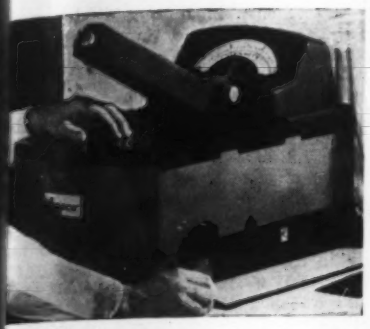
New thermocouple connector panel provides a quick and flexible method for easily connecting any thermocouples of a group to any position on multiple recorders or indicating and controlling pyrometers. Designed for flush mounting and available with any desired number of jacks and plugs. Positive spring jacks firmly hold plugs and are held in place by sub-panel and spacer bolts; screw-fastened type connections facilitate wiring. Positions are numbered on both front and back panels; polarity is indicated only on back. Bakelite plugs have soldered connections and screw fastened covers permitting replacement of cable or plug. Panel is ¼" thick.—*Thermo Electric Co., Fair Lawn, N. J.*



Please mention number 925 when filling out card

Color Analyzer

New color analyzer, designed primarily for photographic work, can be adapted to measuring or matching colors in textiles, paints and dyes, and in medical research; is said to be accurate to approx. 0.02 over entire density



nge. Desired stability is secured by e of a dynode voltage feedback rcuit. A reflection head accessory rmits determination of black-and-hite and color reflection densities of otographic papers, fabrics, pigments, awing, etc. Another accessory simifies measurement of color and denty of liquid solutions (and thereby e concentration) by methods of bridged colorimetry. The 11" measurg arm enables full coverage of up to " width material. Standard recording illiameters may be used with the inrument to obtain a continuous density ecord having linear density scale reding without necessitating any cirit changes.—*Ansco Div., General niline Film Corp., Binghamton, N. Y.*

Please mention number 926 when filling out card

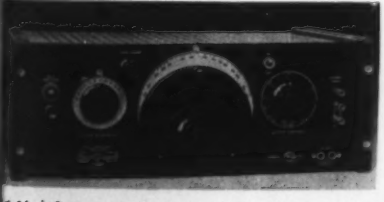
Thermostated Crystal Chamber

New "JKO-7 Stabilized Heat" crystal amber accommodates crystals from to 10,000 kc. and is recommended for broadcast and frequency standard applications. Large 7-pin base. Will accommodate most of maker's holders besides accommodating more than one small holder. Heater 6.3 volts, others on special order. Operating temperature 50°C± 1°, others also on special order. Available as double oven on special order. Crystals electrostatically shielded. Better thermal insulation than that of previous models results in lower heater current consumption and shorter warm-up time. May be mounted in any position.—*James Knights Co., Sandwich, Ill.*

Please mention number 927 when filling out card

Beat-frequency Oscillator

New "Type 1304-A" beat-frequency oscillator supersedes maker's "Type 13-C." Overall frequency range is 20 cycles to 20 kc. with accuracy of ±



1%+0.5 cycle). Illuminated, precision, ear-drive dial has a logarithmic scale.

The new Model BL-310 Strain Measuring Equipment with Brush Direct Inking Oscillograph

Now... for the first time

Immediate RECORDS of STRAINS!

● Here's a strain measuring device that produces records immediately for interpretation. The Brush "STRAIN ANALYZER" consists of a Model BL-310 Strain Amplifier and the Brush Direct-Inking Oscillograph. It's completely self-contained, requiring only two external strain gage connections, one dummy gage and one active gage cemented to the piece being tested.

The equipment records either static or dynamic strains (up to 100 cps) and is phase sensitive so that sense as well as magnitude of the measured strains can be read from the record. The "STRAIN ANALYZER" is readily calibrated for individual gages so that the strain can be read from the chart directly in microinches per inch.

When used with Baldwin Southwark SR-4 Gages of 120 ohm resistance, the maximum sensitivity of the unit is 10 microinches per inch strain per chart division pen deflection. An attenuator switch changes the sensitivity in the following steps: 10, 20, 50, 100, 200, 500, 1000 and 2000 microinches per inch per division. While specifically designed for the 120 ohm gage, the equipment can be used for higher resistance gages. It is also applicable for use with any resistance sensitive pickup and can be used to record pressures, temperatures, accelerations, forces, etc., provided the equipment is calibrated in the terms of the particular pickup used. Investigate the "STRAIN ANALYZER."

Write today for detailed specifications...

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FOR FLIGHT RESEARCH

Specially developed for recording in flight, the TYPE S12-A OSCILLOGRAPH and the TYPE OA-2 GALVANOMETER are ideal for operation under acceleration or vibration.

The TYPE S12-A OSCILLOGRAPH is a complete instrument with internal governor motor, gear-driven record, timing device, record numbering, automatic record-length control, and record footage indicator. Rigid cast aluminum case has carrying strap, measures only ten inches wide by 18 inches long, and weighs only 35 pounds.

Fully described in Technical Bulletin SP-167 B

The TYPE OA-2 GALVANOMETER can be supplied in 66 different combinations of sensitivity and natural frequency, for accurate recording up to 6000 cycles per second. The OA-2 is the only galvanometer suitable for use under extreme vibration or acceleration.

Fully described in Technical Bulletin SP-156 B

The TYPE MRC-12 STRAIN GAGE CONTROL UNIT is the smallest complete six-channel static-dynamic strain gage amplifier and balancing unit in existence. Complete with carrying strap, batteries, six amplifiers, six balancing boxes, and 2000-cycle oscillator, the MRC-12 weighs only 42 pounds.

Fully described in Technical Bulletin SP-177 B

Hathaway
INSTRUMENT COMPANY
1315 SO. CLARKSON STREET • DENVER 10, COLORADO

A frequency increment dial with range of ±50 cycles is provided. Output impedance is 600 ohms, balanced or unbalanced. Normal maximum output 0.3 watt with total distortion of less than 0.25% over most of range. Distortion slightly higher below 100 cycles and above 7500. Maximum output of 1 watt can be obtained. A-c. hum is less than 0.1% of output voltage. Open-circuit output voltages are 25 volts and 4 volts. Output voltage varies less than ±0.25 db over entire frequency range. Frequency drift from a cold start is less than 7 cycles in first hour, and is essentially completed after two hours. Power supply is 105 to 125 (or 210 to 250) volts, 50 to 60 cycles. Total power consumption is 100 watts. The 19" relay-rack panel is 7½" high, and depth behind panel is 14¼". Net weight, 41½ lbs.—*General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*

Please mention number 928 when filling out card

Wiring-inspector's Test Set

New test set enables one person to make a complete test of the wiring in any building without additional help.

Housed in a gray fiber carrying case measuring 14-9/16" × 7-5/16" × 9⅛" high. Total weight 13 lbs. A compartment provides storage space for flexible leads and portable instrument. Power is supplied from a standard 6-volt dry cell.—*Eastern Specialty Co., 3617 N. 8th St., Philadelphia 40, Pa.*

Please mention number 929 when filling out card

Volt-ohm-milliammeter

New "Model 221 Roto-Ranger" is said to be the equivalent of 25 individual instruments. Designed as a high sensitivity a-c.—d-c. volt-ohm-milliammeter and equipped with rotating dials, it is useful for television, radio, and industrial testing. To operate,

selector switch is moved to range desired, the proper scale for that range is brought into place behind window. There are no cramped calibrations; each scale is large and full-sized.—*Simpson Electric Co., 5216 Kinzie St., Chicago 44, Ill.*

Please mention number 930 when filling out card

Appliance Tester

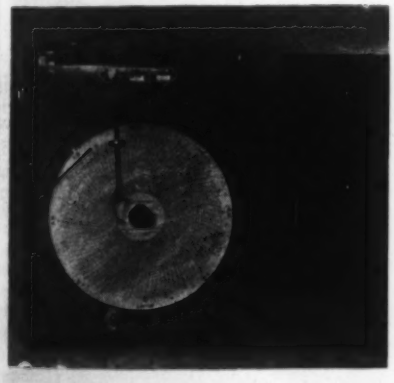
New "Model 900B Volt-Ampere Wattmeter" is designed for testing all a-c. appliances from clocks to 200 volt

electric ranges. Incorporates a current transformer for additional ranges of 5000 and 10,000 watts, and 65 and 130 amperes. Tests appliances under actual use conditions. Shows wattage consumption, amperes and line voltage. A new continuity test consisting of a neon connected between line and load binding posts provides simple but accurate test for shorts in power circuits. Scale length, 3¾".—*Hickok Electrical Instrument Co., 10519 Dupont Ave., Cleveland 8, Ohio.*

Please mention number 931 when filling out card

Multi-range Recording Ammeter and Voltmeter

New portable multi-range d-c. recorder measures micro currents and voltages. Exact range required may be



individually selected by user. Minimum full-scale range of instrument is 0 to 0.1 ma. (100 microamperes) and maximum is 0 to 12 amperes. Sensitivity is 1 part in 1000. Recorder is of the moving-magnet, interchangeable coil type; is designed for continuous duty. Bearing friction and friction between pen and chart are virtually eliminated. Eight different coils are available, each

LOW-RESISTANCE TEST SET #670C
1,000 to 500,000 micro-ohms
(Other ranges from 200 micro-ohms to 100 ohms)

KILOVOLTMETER #785P
AC-DC 5-10-20 KV
(Other ranges from 1.5 to 200 KV)

Shallcross

KELVIN-WHEATSTONE BRIDGE #638-2
0.0001 ohm to 11.11 megohms
(7 additional designs and 15 types of galvanometer limit bridges)

DECADE BOX #825
11,110 ohms in 1 ohm steps
(Other designs, 1 to 7 dials, from 0.1 to 11,111,110 ohms)

. . . for electrical measurements

VOLTAGE DIVIDER (Decade Potentiometer)
10,000 ohms total. Voltage ratio: 0.001 to 1.0
(Other 3- and 4-dial designs, 1,000 to 100,000 ohms)

Shallcross Electrical Measuring Instruments are made in many types — from sturdy, inexpensive bridges for school and production use, to fault location bridges, high-voltage test equipment, low-resistance test sets and numerous others.

Write for Bulletin on any type.

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Dept. IS-98 Collingdale, Pa.

AKRA-OHM PRECISION RESISTORS
14 Standard Types.
50 available special designs.

PRECISION SWITCHES
350 designs for instruments and high-grade electrical apparatus.

ATTENUATORS & CONTROLS FOR COMMUNICATION EQUIPMENT

ANOTHER DU MONT INSTRUMENT FOR ADJUSTING HIGH-SPEED MECHANICAL EQUIPMENT *IN MOTION!*

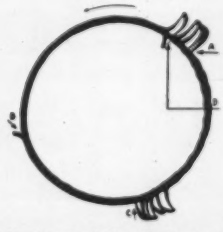
TYPE 275-A
POLAR-COORDINATE
CATHODE-RAY
INDICATOR

● An example of the new methods of Du Mont oscillography is the examination of the motions of the shuttles and heddles of a high-speed loom *under dynamic conditions.* Using the Du Mont Type 275-A Cathode-ray Polar-coordinate Indicator, a full pattern of the loom's action may be studied, *while the loom is running* at full speed. The indicated adjustments are then *rapidly* made for optimum timing of the loom and uniformity of weave with no material in the loom and thus no waste of time and material. Here's how:

As the loom speeds up or slows down, the circular pattern seen with the Type 275-A varies accordingly. This variation is obtained by a simple mechanical connection to the drive shaft of the loom. The exact motion of the heddles relative to the shuttle's position is transmitted to the Type 275-A by pickups on the loom. The oscillograms below show different adjustments of the loom for different weaves.

The best pattern for maximum loom efficiency is determined empirically. When the best adjustment-pattern for a weave is determined, any number of looms may be rapidly and simply adjusted to the same pattern.

Shuttle-heddle timing. A–Shuttle arrives at left side of loom. B–Heddle arrives in upward position. C–Shuttle thrown from left side of loom. D–Heddle starts moving downward.



Shuttle-heddle timing. A–Shuttle arrives at right side of loom. B–Heddle arrives in downward position. C–Shuttle thrown from right side of loom. D–Heddle starts moving up.

Shuttle-heddle timing. A–Shuttle arrives at right side of loom. B–Heddle arrives in upward position. C–Shuttle thrown from right side of loom. D–Heddle starts moving downward.

● The foregoing is but one of the many applications of Du Mont equipment to problems in the field of mechanical engineering. Why not consult us now about applying Du Mont oscillography to your dynamic mechanical application?

DU MONT *for Oscillography*

ALLEN B. DU MONT LABORATORIES, INC., PASSAIC, N. J.
CABLE ADDRESS: ALBEEDU, NEW YORK, N. Y., U. S. A.

adjustable over a range of 11.5 to 1. Scale zero can be suppressed up to 80%. Chart is of the circular 24-hour type and is driven by a conventional synchronous motor consuming approximately 5 watts.—*Wallace & Tiernan Products, Inc., Belleville 9, N. J.*

Please mention number 932 when filling out card

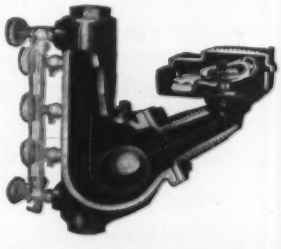
Steam Purity Sample Cooler

New "Model SC-9" sample cooler, for continuous sampling of low-pressure steam, consists of a copper coil within a copper shell, rated to condense 125 lbs./in.^{2} saturated steam. It runs cooled sample through a throttling valve past a thermometer and through a flow type conductivity cell. "Solu-bridges" and "Solu - bridge" recorders are adaptable for use with new cooler. Steam sample inlet and cooling water connections are respectively ⅛" and ⅜" I.P.S. Overall dimensions are 18" × 4½".—*Industrial Instruments, Inc., 17 Pollock Ave., Jersey City 5, N. J.*

Please mention number 933 when filling out card

Boiler Water-level Safety Control

New "No. 157" safety control offers a self-contained water column for high pressure boilers. Designed for maximum steam pressure of 150 lbs./in.^{2}, "No. 157" is similar to maker's "No. 150" but has a new water-column form and makes available low water cut-off, pump control, and low water alarm or any combination of these functions. By making the control an integral part of the water column, practically all equalizing piping and fittings are eliminated. As a result, reproduction of the boiler water level is said to be ideal, and effective, direct blowdown can be provided. All tappings for water-glass and tri-cocks are in the end of the body so that the control may be located on either side of the boiler.—*McDonnell & Miller, Inc., 400 N. Michigan, Chicago 11, Ill.*



Please mention number 934 when filling out card

Microwave Relay Tubes

New "Types 2K26 and 2K25" Klystron tubes are for use principally in microwave relay equipment for television transmission and in multichannel communications equipment. In

transmission, the tubes produce microwaves which travel in comparatively straight paths, permitting line-of-sight transmission without interference. Used for reception, incoming signal is combined with signal of the tube in mixer stage, producing i.f. easily handled by conventional circuits.—*Radio Corp, of America, RCA Victor Div., Camden, N. J.*

Please mention number 935 when filling out card

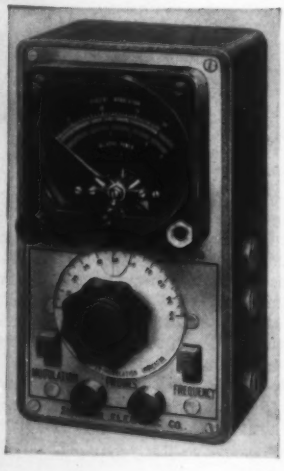
Diamond Penetrators for Hardness Tests

Two new diamond penetrators for Rockwell testing are said to be improved. New "C" diamond penetrator fits all makes of hardness testers for standard Rockwell testing, and new "S" diamond penetrator fits all machines for superficial Rockwell testing. Diamond points are specially selected for proper stratification and freedom from internal stresses. Holders are finished to precisely correct angles and radii. Penetrator is furnished as a standard accessory on maker's hardness testers, both for standard and for superficial Rockwell testing.—*Clark Instrument, Inc., 10200 Ford Rd., Dearborn, Mich.*

Please mention number 936 when filling out card

Wavemeter and Modulation Indicator

New "Model 380" pocket-size control unit makes it possible to monitor accurately quality of transmission, spot a transmitter at any point on the band desired, and keep constant check on percentage modulation. Encased in aluminum, wavemeter serves also to plot antenna field patterns, indicate changes in actual radiated power output, and search the region between bands for harmonics and parasitics. Separate coils for the 10-, 20-, 40- and 80-meter bands, and hand-drawn calibration curves are supplied. For cover-



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For pressures and vacuums . . . with ranges from water inches up to 30,000 P. S. I. . . . there's an ACRAGAGE scientifically designed to give you dependable precision on steam, oil, gas, chemicals, water, or brine. ACRAGAGE comes in a wide variety of sizes — 4½", 6", 8½", or 10", with wall, stem, or true flush mountings. ACRAGAGE cuts down your operating expense . . . protects you against costly errors and inaccuracies.

20% to 30% Longer *Bourdon* Tubes

Bourdon tubes in the ACRAGAGE are 20% to 30% longer than average . . . resulting in the following advantages: less strain per unit length on the spring; increased durability; longer fatigue life; heavier wall thickness for added safety; greater tip-travel — providing sustained accuracies to within one-half of one percent!

Remember ACRAGAGE — a quality product made by skilled craftsmen from materials which meet rigid standards, including Army and Navy specifications.

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WEBSTER, MASS.

age of all possible field strength conditions, the 2' antenna furnished can be plugged into panel jack. Range of instrument covers bands up to and including 420 Mc.—*Simpson Electric Co., 5216 Kinzie St., Chicago 44, Ill.*

Please mention number 937 when filling out card

Air Velocity Meter

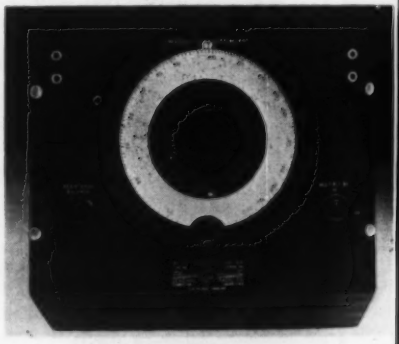
New "Airite Velocity Meter" indicates velocity of air movement in an open space. Velocity is indicated—

directly in ft./min. on a calibrated scale — by positioning instrument against air flow. Range is 0-1200 ft./min. Dimensions are 3⅜" × 3⅜" × 1⅝". Detachable handle facilitates use on baseboard or low sidewall registers. Unusual features include an 8" scale with 20 ft./min. divisions, and a lock by means of which scale reading may be retained until lock is released.—*Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh 8, Pa.*

Please mention number 938 when filling out card

Bridge-type Audio-frequency Meter

"Type 1141-A" bridge-type frequency meter (discontinued during war) is again available. Features are wide

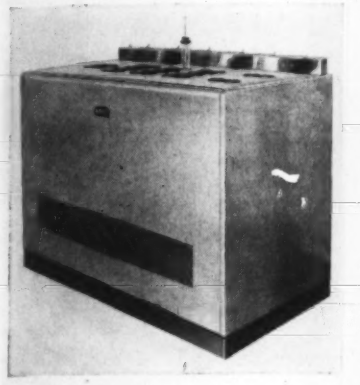


range (20 to 20,000 cycles) and high accuracy (0.5%). Precise frequency settings can be made because of the null method used. Null detector can be either headphones or a vacuum-tube voltmeter. Inherent frequency response characteristics of the Wien bridge circuit also permit the instrument to be used as an adjustable-frequency filter. Over-all dimensions 12" × 8¾" × 9". Net weight, 15¼ lbs.—*General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*

Please mention number 939 when filling out card

Cloud and Pour Test Apparatus

New cloud and pour test unit conforms with ASTM, API and ASA standards for all cloud and pour testing. It is said to be unique in that two more temperature factors, +77°F. and +118°F. (as outlined in the Procedure for Pour Pont, Par. 5C ASTM Spec. D97-47), and an adjustable factor from —60°F. to —80°F. for determination of very low pour points, have been provided. Stainless steel tanks contain 32

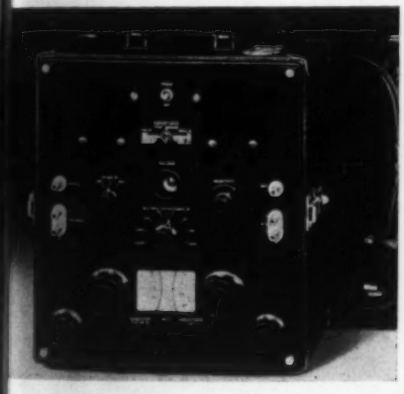


copper sleeve test tube inserts with four sleeves from —60°F. to —80°F., eight at —30°F., eight at 0°F., eight at +30°F., two at +77°F., and two at +118°F. Temperatures are controlled by built-in thermostats. Cabinet measures 52" wide × 39" high × 27" deep. Current required, 110 volts, 60 cycles, S.Ph., a.c. Refrigeration is provided by self-contained two-stage air-cooled condensing unit.—*Bowser, Inc., Refrigeration Div., Terryville, Conn.*

Please mention number 940 when filling out card

Wide-range Capacitance Test Bridge

New "Type 1611-A" capacitance test bridge measures capacitance over the extremely wide range of 1 μμf. to 10,000

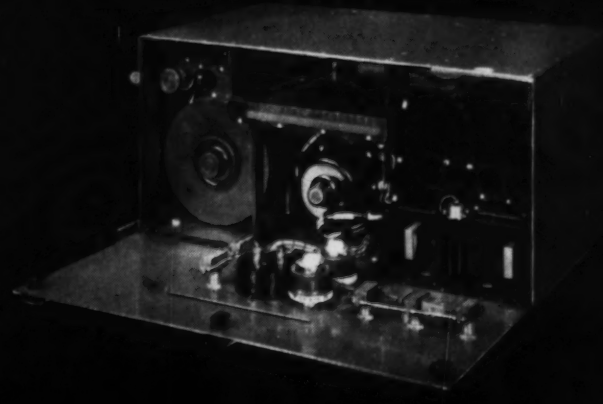


μf., a total spread of 10 billion to one. Over this entire range an accuracy of ± (1% + 1 μμf.) is maintained. Dissipation factor range is 0 to 60%, and frequency of test voltage is 60 cycles. Bridge is useful for measuring all types of capacitors, also for shop testing of bushings and insulators. Facilities are provided for introducing a polarizing voltage for measurement of electrolytic capacitors. A feature is a unique zero-compensating circuit that balances out

Century

PORTABLE OSCILLOGRAPH

A portable oscillograph for laboratory or field use; this instrument incorporates high standards of accuracy with rugged dependability.



Available with banks of from four to twenty-five hermetrically sealed, pencil-type Century galvanometers in a wide selection of frequencies and sensitivities, this instrument faithfully reproduces on positive recording film bearing simultaneously superimposed timing lines.

Paper widths from 35 mm to 6 inches and a wide range of synchronous motor and tuning fork components are available for operation from 110 volts in the laboratory or for 12-24 volts d.c. truck or aircraft operation. Completely portable daylight developing equipment obtainable if required.

A letter of inquiry regarding the application of this instrument to your needs will receive the prompt attention of our engineers.

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DIVISION OF THE SPERRY CORPORATION
31-10 THOMSON AVENUE
LONG ISLAND CITY 1, N. Y.

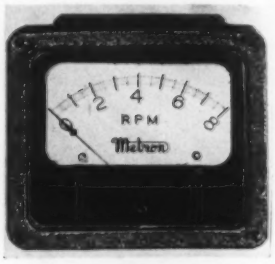
ESTABLISHED 1915

initial capacitance and dissipation factor at zero setting of dials. Bridge is completely self-contained, including visual null detector and operates from 60-cycle power line. Over-all dimensions are 14½" × 16" × 10". Net weight, 30½ lbs.—*General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*

Please mention number 941 when filling out card

Universal Tachometer Indicator

New "Type 43" single-range indicator is for use with any of maker's



tachometer heads; is of rugged design and shock mounted in sponge rubber to permit use where severe shock or vibration is present. Aluminum housing provides flush switchboard mounting from front or bracket mounting from bottom. Electrical head connections are made to terminals on rear surface. Also on rear is a calibration adjustment. Scale length, 4"; range, 1 r.p.m. to 100,000 r.p.m.—*Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.*

Please mention number 942 when filling out card

EBERBACH
LABORATORY SHAKERS

New silent operating shakers with special carriers for utility shaking as shown or flasks (not illustrated). Carriers are interchangeable on bases which are available with four different speed characteristics.

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Eberbach & Son Company
LABORATORY APPARATUS & SUPPLIES
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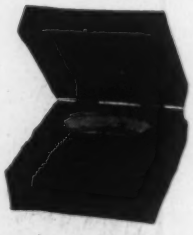


RAWSON FLUXMETER TYPE 504

The only portable fluxmeter available which returns rapidly to zero when a single button is depressed. Simple and fast in operation. Convenient and light in weight.

Not limited to a single type of measurement. Has universal application for laboratories or production. Measures strength of magnets and electromagnets, permeability and hysteresis loops for iron and steel, total flux lines in circuit, flux lines developed in air gap, etc.

Has a mechanical clamp to protect the pivots and jewels when in transit.

RAWSON ELECTRICAL INSTRUMENT COMPANY
112 POTTER STREET, CAMBRIDGE 42, MASS.

Representatives

CHICAGO NEW YORK CITY
LOS ANGELES

Battery Tester

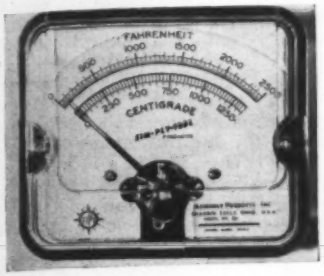
New pocket-size dry-battery tester has an accuracy of 1%. Rotary switch selects voltage of battery under test and brings into line correct loading resistor. A percentage scale shows condition of battery in percentage of full voltage. Needle-point prods (furnished) assure positive contact regardless of

type of terminal on battery. Three arcs are shown on 3" scale; one for radio A batteries, one for hearing aid B batteries, and one for all B batteries. Each is marked in three sections, "good," "weak," and "bad."—*Simpson Electric Co., 5216 Kinzie St., Chicago, Ill.*

Please mention number 943 when filling out card

Indicating Instruments for Thermoelectric Pyrometers

New pyrometer indicators have 3" dials calibrated in both Fahrenheit and Centigrade. Case measures 3¾" wide, 3⅝" high and has one-piece plastic front. Offered in several ranges up to 2500°F. and 1370°C. Four ohms per millivolt gives resistance of 212 ohms for 2500°F. Thermocouples do not need calibrated leads. Instruments are calibrated for 10 ohms external resistance (8 ohms for 500° range). A suitable

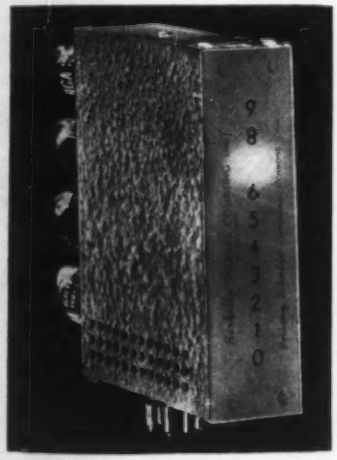


resistance spool, connected in thermocouple circuit, is brought out to an extra terminal on back. With this in circuit, thermocouples with uncalibrated leads up to 15 feet long are used. When longer leads are required, this resistance is left out of circuit. Accommodates leads up to 100' long. Internal construction features Alnico V magnets, polished pivots in sapphire jewels and phosphor bronze hairsprings. Instruments are balanced and may be used in any position. Fully compensated for ambient temperature. —*Assembly Products, Inc., Main & Bell Sts., Chagrin Falls, Ohio.*

Please mention number 944 when filling out card

High-speed Decimal Counter

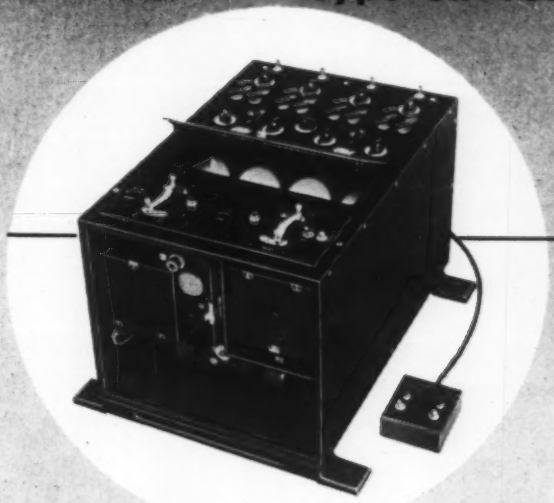
New "Decimal Counting Unit" is capable of operating continuously at rates in excess of 40,000 counts per second and of resolving paired pulses spaced less than 10 microseconds apart. Unit contains four tubes of latest type



and employs an especially-developed construction technique which permits all circuit components (except tubes) to be housed in a case measuring only 5" × 3½" × 1⅜". All connections are made through a conventional octal socket so that unit may be plugged in

FOR PERMANENT RECORDS
of High Speed Phenomena

The New HEILAND
CATHODE-RAY RECORDER
Type CR-43A



The HEILAND CR-43A Cathode-Ray Recorder has four recording channels, each consisting of a one-stage balanced amplifier direct-coupled to a 3" short persistence Cathode-Ray tube. Records of the waves appearing on the tube screen are made by a 35mm. built-in camera which can be operated at one of four quickly selected speeds. The optical system may be shifted to photograph either 2 or 4 channels. A fork-controlled discharge tube produces 100 time marks per second.

Daylight loading magazines assure easy film loading. A viewing door provides convenient visual observation.

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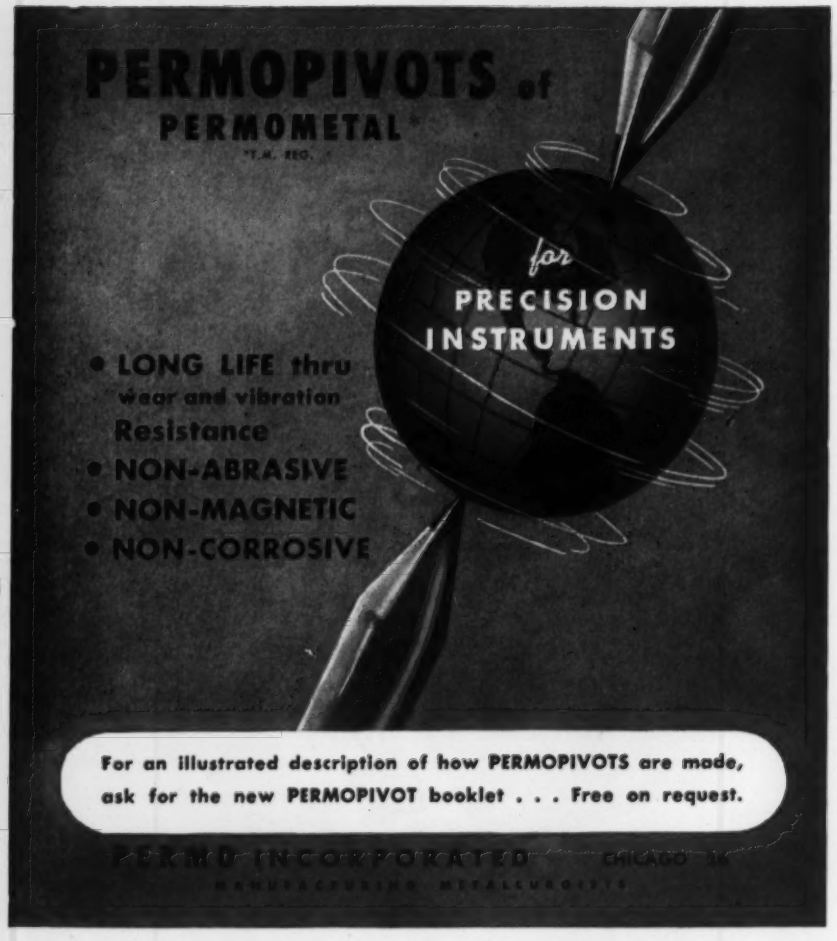

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THERMOCOUPLE
MODEL 4000 — for wall type indicator or recorder. Has flexible arm adjustable to any angle without use of tools
For Instantly and Accurately
Checking the Temperature of all
Nonferrous Molten Metals
"METALAST" SPEEDY
tips are made of a special heat-resisting alloy which will give SPEED plus DURABILITY plus ACCURACY.
METALAST SPEEDY JUNIOR—¼" pipe size, for quick response—thermocouples are made of 16 gauge wire.
METALAST SPEEDY STANDARD—½" pipe size, heavy duty—thermocouples are made of 8 or 11 gauge wire.
Tubes may be straight, as well as 45 or 90 degree angles.
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For further information—write to
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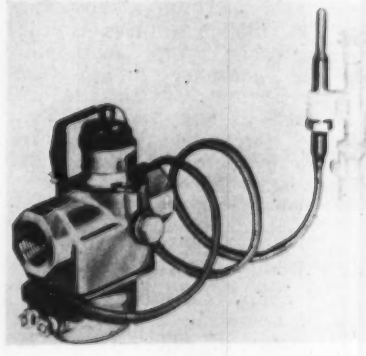
1150 W. MARQUETTE ROAD CHICAGO 21, ILLINOIS

and exchanged like a radio tube. Ten neon indicator lamps are mounted behind Lucite front panel numbered from zero to nine. Each count is indicated directly by illuminating neon lamp corresponding to number of pulses received. Any number of Units may be cascaded to count to any desired number. By mounting several Units next to each other, number registered may be read directly. (If, for example, four Units are used, a total count of 7,059 will cause numerals, 7, 0, 5, and 9 to light up in first, second, third, and fourth Unit respectively.) Reset to zero is accomplished by pressing a momentary-contact switch. In addition to straightforward counting, new Units will be found useful in accurate measurement of time intervals and frequency measurement; and in control of events for a predetermined time or counting cycle. Maker's Engineering Department is prepared to develop special devices incorporating new Unit. —*Berkeley Scientific Co., 6th and Nevin Ave., Richmond, Calif.*

Please mention number 945 when filling out card

Automatic Gas Shut-off

New "MR-2-5" shutoff is an all-in-one, simplified, on-off and safety shut-off control unit for floor, central, small

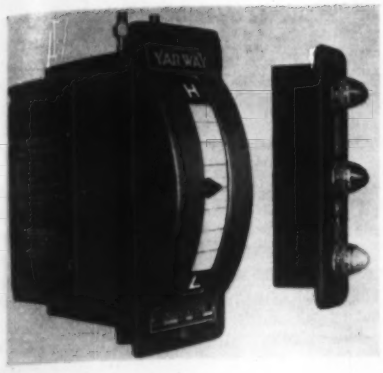


space and water heaters. Flow of gas stops when pilot is extinguished. During reset operation, gas flows to pilot burner only. No gas can pass to main burner until the pilot is ignited and the safety valve set in the operating position. Operator can then simply set single handle control for any desired gas flow to the main burner. Safety valve mechanism is fully protected by a complete seal against air-borne or gas-borne foreign matter or scum-forming vapors. Accessible thermocouple terminals permit check of couple or valve operation under normal operating conditions and without breaking connections.—*General Controls Co., 801 Allen Ave., Glendale 1, Calif.*

Please mention number 946 when filling out card

Water Level Signal Indicator

New attachment for maker's remote liquid level indicator operates one or more distantly-located electric type visible or audible high-low alarm signals and/or controllers for pump motors or other devices in steam power stations and industrial plants. Unit is attached directly to indicator. Control unit consists of two-pole curved-bar permanent magnet fixed to shaft of in-



dicator pointer and actuating one or the other of two sealed-in glass mercury switches which in turn operate high-low alarm signals installed at remote locations. Visible signal shows red light at top or bottom for high-level or low-level condition corresponding to high-low positions of indicator pointer; center lens shows green or amber during normal level range of indicator. Audible signal uses two vibrating horns of different tones or a single horn for both high and low levels.—*Yarnall-Waring Co., Chestnut Hill, Philadelphia 18, Pa.*

Please mention number 947 when filling out card

Polystyrene Capacitors

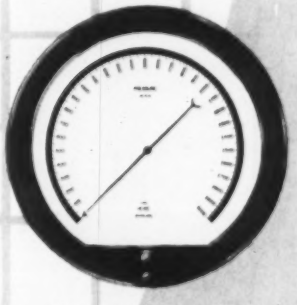
New line of polystyrene-film dielectric capacitors are claimed to be unexcelled for applications where extremely high insulation resistance, large capacitance with high "Q", or extremely low dielectric absorption are required. Polystyrene capacitors store charge for "long periods of time" then discharge instantly.—*Solar Manufacturing Corp., 1445 Hudson Blvd., North Bergen, N. J.*

Please mention number 948 when filling out card

24-channel Strain Gages

New "Model 301" strain gage (illustrated) and new "Model 302" bridge balancer permit rapid, convenient reading of strains in multiple-wire resistance strain gage tests. Capable of accommodating 24 strain gages of wire resistance type, these instruments are said to obviate need of disconnecting and reconnecting gage wires for multiple-gage tests; also separate zero load readings for each gage can be dispensed with by using built-in zero load bridge balancers. Gages of resistance from a few to several thousand ohms

a bourdon tube of special design for every application



HEISE GAUGES

STANDARD OF THE WORLD

Heise pressure gauges employ an infinite number of Bourdon tube designs to reduce fibre stress to a point where the gauge can be used continuously at maximum calibration. There is no standard design. Every Heise Bourdon tube is designed for maximum stability and accuracy in a selected range and pressure medium.

Three sizes: 8½ in., 12 in., and 16 in., in ranges from 0-15 to 0-10,000 psi. Prices from $151.60 to $211.20. Write for catalog.

Heise Bourdon Tube Company, Inc.
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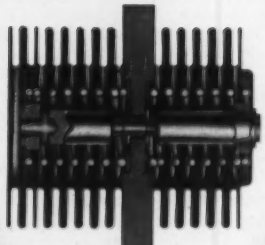

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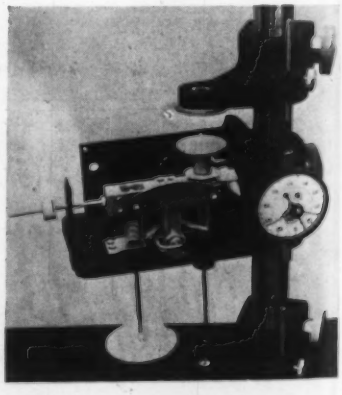

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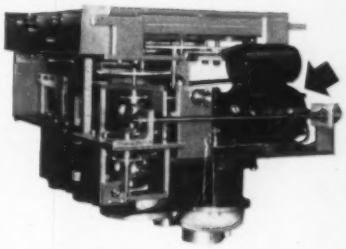

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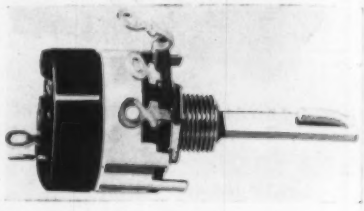

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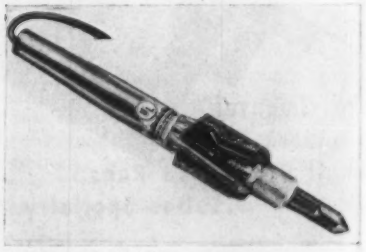

sulator and cooling fins are used. A ceramic separator eliminates possibility of short, according to manufacturer, and a spring-action rivet takes up expansion to keep positive contact with heating unit. Element is 20-watt for use with 110-120 volt a.c. or d.c. Four interchangeable tellurium tips: ⅛" chisel, ⅛" pencil, ⅝" chisel, and ⅜" pyramid. Copper tip length beyond heating coil is ⅝" on ⅜" tips and ⅞" on ⅛" tips. Both heat to 600° in 90 seconds. Soldering pencil is 7" long; max. dia. 1". Underwriters' listed seal is on complete pencil set.—*Ungar Electric Tool Co., Los Angeles 54, Calif.*

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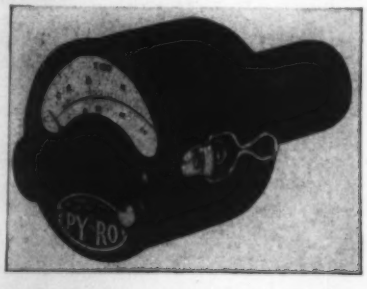

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The Polarograph *as an* Analytical Tool *in* Industry

By MARTHA J. BERGIN, Sylvania Electric Products Inc., Salem, Mass.

ABOUT 25 years ago the polarographic method of analysis was introduced by Professor Jaroslav Heyrovsky, its inventor. Perhaps more than any other analytical tool the polarograph was at first praised to a point where it seemed to spell the end for analytical chemists. Conversely, when later it was found that the new instrument was not an automatic chemist which could be operated by any layman, it was discarded by industry and left to the more academic type of research.

Recently, however, the polarograph has come into its own as a valuable tool for industry. Although a skilled chemist is necessary to operate it, especially during the preliminary procedures, the time saved, the elements which are more easily analyzed, and the accuracy with which they are analyzed has brought the polarographic method into industrial control and research laboratories. At present it is used in some analytical laboratories as a standard apparatus for routine analyses; in others it is still the object of a great deal of research; in still others it has not been considered an analytical tool. However, as new editions of scientific journals provide new uses for it, the polarograph is taking its rightful place among the instruments of the analytical chemist.

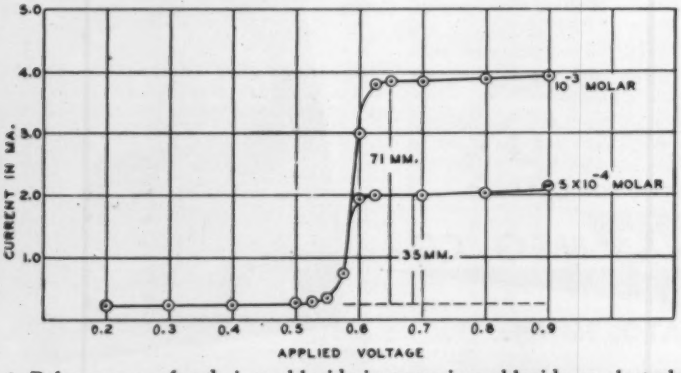


Fig. 1. Polarograms of cadmium chloride in potassium chloride as electrolyte.

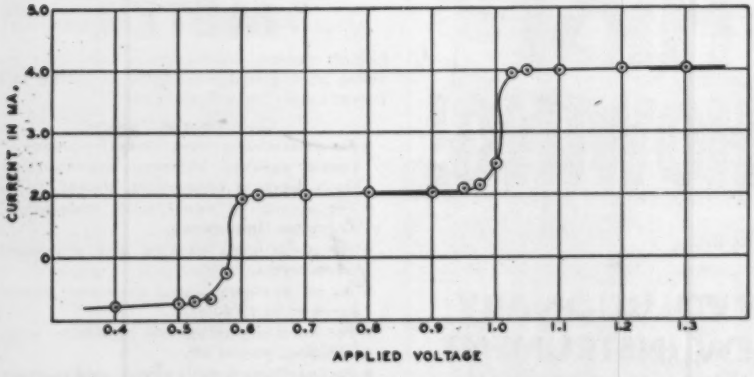


Fig. 2. Polarogram of equimolar cadmium-zinc chloride in potassium chloride as electrolyte.

Principles

The basic principle in polarography is simply an electrolysis. Electrolysis may be defined as the occurrence of a chemical reaction, caused by an electromotive force, between electrodes immersed in an electrolyte. During electrolysis the ions flow through the electrolyte between the electrodes. If the electromotive force which is applied to the system is plotted against the resulting current, a current-voltage curve is obtained. It is this type of curve that the polarograph records, from which the information about the analysis is obtained.

If a solution, containing no unknown substance which can be oxidized or reduced in the voltage range applied, is analyzed, a horizontal straight-line current-voltage curve is obtained. However, if there is a foreign ion present which can be reduced, it will depolarize* the electrode as the increasing electromotive force reaches a critical voltage, causing a sudden increase in the current. As the voltage further increases, this current approaches a limiting value and finally becomes constant. The difference between this limiting value and the initial residual current is directly proportional to the concentration of the ion present in the solution. Thus, by comparing this "wave" height with that of a known concentration of the ion (all other factors but concentration having been held constant) a quantitative result may be obtained.

Typical current-voltage curves are shown in Fig. 1. In this case two solutions of cadmium were electrolyzed, one just half the concentration of the other. It will be noticed that the wave heights are in the ratio of 71/35 or approximately two to one. From this height a direct quantitative analysis can be made, i.e. one solution has twice as much cadmium as the other.

The potential difference which is most characteristic for each substance is the "half-wave" potential. This is defined as the potential difference at the point on a current voltage curve where the current is equal to one half the limiting value, assuming a residual current of 0.0 amp. In the case of cadmium electrolyzed in a 0.1 *N* potassium chloride solution, the half-wave potential difference is 0.590 volts (*vs.* standard calomel electrode at 25°C.) This half-wave potential difference does not change with cadmium concentration.

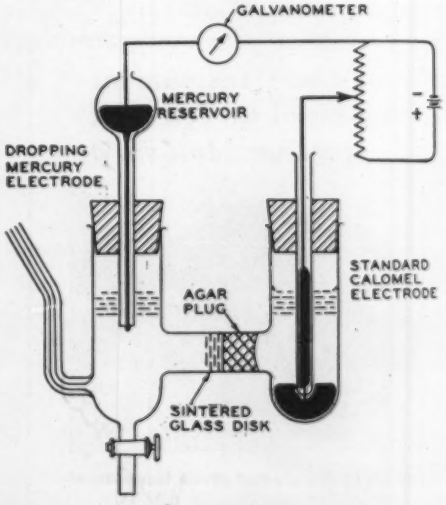


Fig. 3. Schematic representation of apparatus for polarographic analysis.

One of the great virtues of the polarograph is that it can analyze simultaneously more than one element

*Strictly speaking, the term "depolarize" is misapplied by polarographers. However, by wide usage it has gained acceptance in the sense used by the author.

in the solution. (See Fig. 2). Each element produces its own current-voltage curve at its characteristic potential difference. If these potential differences are great enough so that the waves do not overlap, both quantitative and qualitative analyses can be made of each element. In some ideal situations, as many as five substances have been determined at one time.

As yet, in this discussion of principles, the identifying part of the polarograph, i.e. the dropping mercury electrode, has been omitted. (See Fig. 3). In order that the change of current due to electroreducible elements may be measured accurately, a special type of sensitive cell and special electrodes are used. In the first place, the system must be arranged so that the reaction at only one electrode is measured. To do this, a small dropping-mercury electrode is used against a standard unchanging electrode (usually a saturated calomel electrode). The changes are measured at the smaller, more sensitive mercury electrode. Secondly, as the ions migrate to the electrode and plate, in order to prevent polarization, a fresh surface of mercury must be constantly exposed thus giving the most accurate results. Here again the dropping-mercury electrode fits in perfectly, giving a new surface as the mercury drop grows and then falls off. Fig. 3 shows schematically the variable source of applied voltage; in practice, a motor-driven voltage divider is used, as shown in Fig. 4. A front view of the equipment in use at General Engineering is given in Fig. 5. The recorder on which are plotted the current-voltage curves is clearly visible in Fig. 4.

Sensitivity and Accuracy

A factor which is often very advantageous in analytical work is the low concentrations at which an analysis can be made. The polarographic method is applicable over a concentration range from 10^{-6} to 10^{-2} molar. The ideal working range, however, is between 10^{-3} to 10^{-4} molar. In the concentration range of 10^{-2} to 10^{-5} *m.* an accuracy of between 1% and 3% is obtained depending mostly on factors in the analyzed solution. Below 10^{-5} molar the accuracy decreases so rapidly as to make the method inapplicable.

Scope

The scope of the polarographic method includes theoretically any substance which may be electro-oxidized or reduced. Because of the large size of the field which is opened, the method has been applied to a rather small section of the whole. In the inorganic field, which has been the most completely investigated, all metallic ions, and a number of complex anions such as chromate, bromate, and nitrate, may be analyzed. Another interesting field, which has barely been touched, applies to gases dissolved in an electrolyte. Oxygen analysis by this method has proved especially valuable in biochemical studies to measure the respiration of certain organisms. Other gases which may be analyzed by the polarograph include cyanogen and sulphur dioxide. Organic chemistry has hardly been surveyed by the polarograph although the applications seem numerous. Perhaps in this field, if primary indications are true, the polarograph will supply a valuable and much-needed tool in analytical organic chemistry. Also in connection with organic analyses, the polarograph is being used quite extensively in cancer research.

Applications

The polarograph is rapidly taking an important position in industrial analysis. A primary advantage it has over many procedures is the rapidity with which an analysis can be made. The main difficulty is placing the sample in solution with the proper electrolyte and at the proper concentration. An equivalent problem exists in any analytical procedure. Once the procedure is set up, a current-voltage curve is made and results obtained directly from the curve. In many cases, especially control work, it is not necessary to have a series of standards or even to compute the exact percentage of the element. A polarogram (current-voltage curve) is made of the sample known to be acceptable. Any difference in composition is easily detected. Another interesting advantage in this procedure is that *the solution is not changed appreciably by this analysis* and it may be used if further tests are desired.

The low concentration at which the polarograph operates can be used ideally in two ways in industry. Either a very small sample may be used to obtain major components; or trace elements may be determined by using a larger sample. The former is advantageous when there is a limited quantity of an unknown sample to be

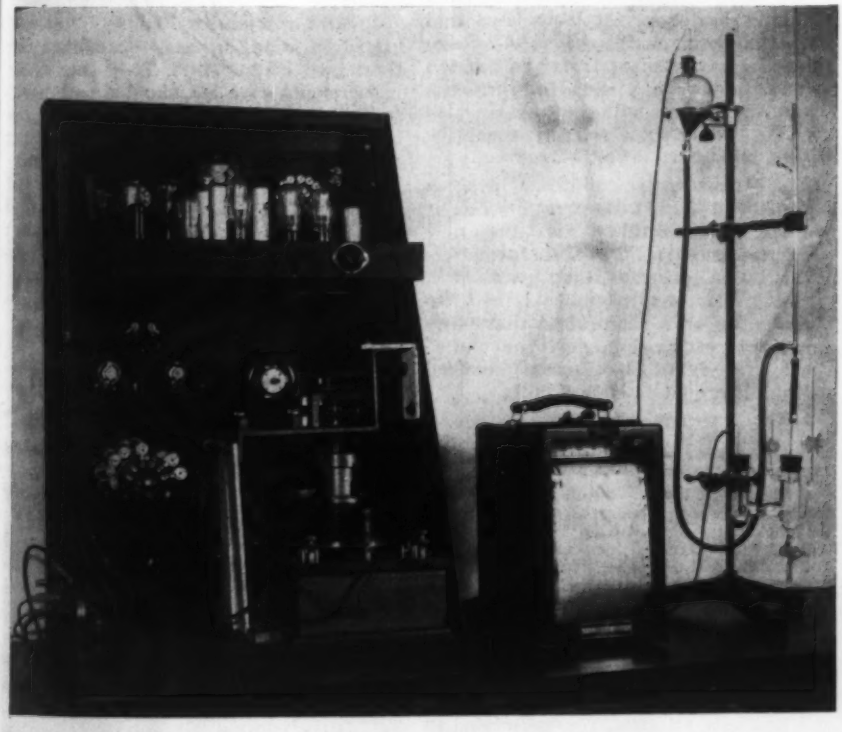


Fig. 4. Polarograph assembly in Sylvania Electric laboratory. Photograph includes a rear view of cabinet, showing important details. This polarograph (including electrode assembly) was designed and built under the direction of James H. Schulman while he was at Sylvania Electric. It is believed to be outstanding in sensitivity and in rapidity of analysis.

Fig. 5. Front view of polarograph cabinet at Sylvania Electric laboratory.

analyzed. The latter is used to detect impurities in chemicals, especially by chemical manufacturing companies. The range of the polarograph is as sensitive as any colorimetric procedure and extends into the low-sensitivity limits of the spectrographic range.

Perhaps the advantage of the polarographic method which is most singular is its ability to analyze quickly and simultaneously *complex mixtures of elements*. Combinations which include several metals, such as nickel and cobalt or cadmium and zinc, are extremely difficult to analyze quantitatively by ordinary analytical methods. First, such elements must be separated and, as their properties are so much alike, this often means a long involved procedure followed by the individual determination of each. The length and complexity of these procedures often cause doubt as to the accuracy of the final results. In the case of the polarograph the elements need not be separated, as the half-wave potentials of the two elements are sufficiently far apart so that the individual waves may be obtained.

Another group of elements causing difficulty when in a mixture includes barium, strontium, and calcium. The polarograph is not quite so applicable to this problem, for the elements plate out at such a high voltage that the electrolyte itself often decomposes before the voltage necessary to reduce the alkali-earth cations is reached. The chemical nature of the electrolyte, in which the unknown is dissolved, is important in the polarographic method, since a variation of concentration or type of dissolved salts may mean a change of the half-wave potential. Therefore, the method of insuring accurate results is to treat the standard solution exactly as the unknown must be treated. However, this dependence on electrolyte may be used to advantage in separating overlapping elements via electrolytic change.

Electrical Instrument Calibrating *for* Industry

By WILLIAM L. KINSELL, System Engineer, Bendix Radio, Towson, Md.*

IN the use of electrical indicating instruments—particularly in the research, development, production and maintenance activities of industry—the ACCURACY of such instruments is rather generally recognized by their users as one of the most serious considerations in the proper conduct of these activities, and at the same time one which receives inadequate attention. Instrument calibration may be neglected because of lack of calibrating equipment. Often, however, it is neglected because of the cumbersome and time-consuming arrangements which result from an unplanned activity. This article outlines the factors that must be considered and presents one arrangement which will fill the need for a flexible, efficient, safe and time-saving calibrating apparatus.

Our Dependence Upon Accurate Instruments

Anyone associated in an engineering or technical way with an electronic or electrical business knows that much of the work done in developing, testing, maintaining or using equipment involves the use of electrical instruments. Development of such products involves the design of circuits and the subsequent assembling of models, upon which all desirable electrical measurements are made to determine the adequacy of each model's performance. Later, when the equipment is placed in production, the factory test department likewise makes electrical measurements to determine that the finished product performs in the same satisfactory manner.

The customer who buys the product often is equipped to make acceptance measurements and tests. He too may maintain a service department to take care of the equipment, or he may contract with a specialist to do it for him. In any event, electrical instruments are used liberally throughout the entire program.

Instruments not regularly calibrated may develop errors, either through careless use or because of inadequate quality. Many users forget this and continue to use inaccurate instruments until a serious situation grows out of it.

A Specific Case

Suppose that a development engineer for an electronic apparatus manufacturer, in designing a new equipment, builds a model of the new item and finds that a given transformer voltage should be within one-quarter volt of ten volts at one-ampere load. He specifies a transformer that will do this. He also specifies that this voltage must be within one-quarter volt of correct.

The transformer supplier designs and tests a transformer and sends it to the manufacturer for the new product. In turn, the transformer is tested by an inspector, then installed in a unit. When an attempt is made to operate the unit, it is found that more voltage is required for proper operation. A study of the factors involved in this discrepancy shows that:

1. The electronic design engineer's voltmeter may have been inaccurate. (It was found that when his instrument read 10 volts, he actually had 10.3 volts.)
2. The transformer supplier's voltmeter may have been inaccurate. (It was found that his voltmeter read 0.3 volts high. The transformer actually delivered 9.5 volts, but his voltmeter read 9.8, which is within the one-quarter volt tolerance.)
3. The Inspection Department's voltmeter may have been inaccurate. (It was found that it read the same as the transformer manufacturer's.)

The net result is that where the engineer used 10.3 volts in his model, the production unit had only 9.5 volts. The voltmeters all indicated within the allowable 2½% tolerance, but the final result was approximately 8% off. In other words, the final result may be in error by the tolerance specified for the transformer, or other component, plus the percent errors of the instruments.

This illustration is presented to show how dependent we are on the accuracy of electrical indicating instruments, to indicate the importance of providing means for checking it. Any technical man—from a research engineer to a maintenance man—is quite aware of his utter helplessness when his instruments are of questionable accuracy. The results may easily be serious financial difficulties and/or lost time. Such situations may be prevented by periodically calibrating or checking the accuracy of the instruments involved.

Instrument Calibrating

Small companies usually cannot afford to install means for calibrating their own instruments. They take their instruments to a standardizing laboratory for such service. However, a larger firm will find it practical to set up at least a simplified instrument calibrating equipment. And of course, if large enough, the organization will find it advantageous to provide equipment for calibrating all indicating instruments it may have in its stock.

Instruments are known by their general class of use, as follows:

1. Service Instruments, 2 to 5% accuracy
2. Panel Instruments, 2 to 5% accuracy
3. Portable Testing Instruments, ¾ to 1% accuracy
4. Switchboard Instruments, ¾ to 1% accuracy
5. Portable or Secondary Standard Instruments, ¼ to ½% accuracy
6. Primary Standard Instruments, 1/10% accuracy
7. Primary Standard Cells, 1/100% accuracy

Any of these classes of instruments may be calibrated by comparing it with one of greater accuracy, or with one in a higher classification in the above tabulation, provided that the instrument being used as the standard is known to be within its rated accuracy. When such a calibration is made, the instrument reading may be in error by the tolerance of the standard; there-

*The development described in this article was done while the author was Engineer in Charge of Test Equipment at Farnsworth Television and Radio Corp., Fort Wayne, Indiana.

fore, the degree of accuracy attained will depend upon the standard being used.

It should be emphasized that since the calibrations depend upon the accuracy of the standard, a means of detecting errors in the standard should be provided. In effect, the only provision for this is found in maintaining two independent standards. Then, if at any time the two standards do not agree, it is obvious that one of them is in error and both should be calibrated. A further improvement in this arrangement is the maintaining of three standards. Then if one standard changes, the other two still will agree and only one will require calibration. The advantage of this arrangement is that the user is never without a standard.

Use of Standard Cells for D-c. Calibrations

A standard cell is a voltage source of approximately 1.0186 volts, accurate and stable to within 1/100%. By means of the circuit shown in Fig. 1, a d-c. voltmeter V of any range may be calibrated. The supply voltage and divider ratio are set so that voltmeter V reads as desired and galvanometer G shows no deflection. Voltmeter V should then read E_s, the standard cell voltage, times the divider ratio, if it does not, the difference is the instrument correction for that particular voltage.

Fig. 2 shows the calibration of a d-c. ammeter, A. In this circuit the balance is made between the standard cell and shunt resistor S, through which the current flows. The current may readily be calculated, and is the value which the instrument should indicate.

Since the accuracy of the calibrations depends not only on the standard cell E_s, but also on divider D for voltage calibrations and shunt S for current calibrations, it is obvious that these two units must be accurate to a degree equal to that desired in the over-all calibration or better. Precision resistors are available with accuracies considerably better than 0.1% and may be checked at intervals by a precision Wheatstone bridge to assure the maintenance of their accuracy.

Calibration of A-c. Instruments

Since the above procedure may be used only with d-c. instruments, a means must be employed to transfer from d.c. to a.c. This is done in two steps:

1. Calibrate an electrodynamometer type instrument using the d-c. method described above.

2. Use the calibrated electrodynamometer instrument as a standard on a.c.

It should be explained that an electrodynamometer type instrument is one which reads true RMS values unless the source contains harmonics of frequencies above the useful range of the instrument. Thus it reads correctly on d.c. or a.c. and, if calibrated on d.c., may be used as a standard for a-c. calibrations. By this means, then, a standard of high accuracy is furnished for a-c. calibration. For highest accuracy, an instrument of the Primary Standard class would be used.

Practical Calibration of D-c. Instruments

The calibration of d-c. instruments by use of the standard cell is highly precise but is rather cumbersome and slow. It is much more satisfactory, where such precision is not required, to

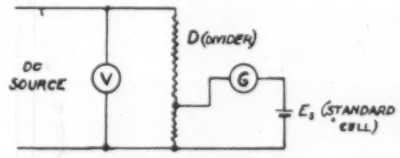


Fig 1

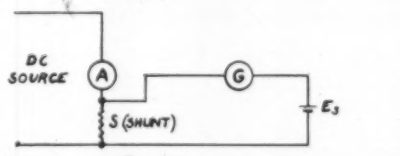


Fig. 2

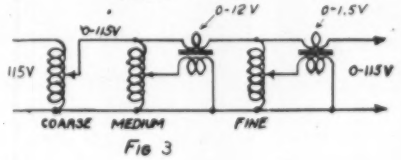


Fig 3

use the standard cell to calibrate a d-c. Primary Standard instrument, which may then be used to calibrate other d-c. instruments. This Primary Standard would be checked only occasionally since, if it is properly used, there is little likelihood of its accuracy falling off.

Calibrating-system Requirements

There are as many arrangements for the use of the calibrating apparatus as there are users of it. However, some desirable details may be included for obtaining best results most conveniently, with a minimum of confusion and least possibility for error or damage to the standards.

One of the first requirements for the proper use of standards is physical protection. Since a standard instrument is worth several hundred dollars and is relatively fragile, it should be permanently mounted, preferably in a glass-covered case, so that it is never moved. It may be cushioned if subject to shock or vibration. The wiring is then brought out to a panel.

Next, electrical protection against overload is achieved by providing power supplies of such design that current or voltage is limited to safe values. This means that for voltmeters, voltage supplies must not be capable of furnishing a voltage high enough to damage the standard, and current supplies must employ current-limiting resistors that will likewise protect the current standard. It is true that this results in a large number of power supplies, but the actual cost of the supplies is much less than of the standards themselves.

The third requirement is for means by which the standard instruments may be calibrated. Three standard cells should be employed, to permit detecting the bad cell if a discrepancy should appear. By employing the standard cells with a precision potentiometer and precision multipliers and shunts, which may in turn be maintained by checking with a precision resistance bridge, a large range of voltages and currents may be measured and the standard instruments may be included in the circuits and calibrated.

Fourth, since no instrument is accurate at low scale readings, standards should be chosen with such scale ranges that any value of current or voltage may be checked at a reasonably high scale reading. It is practical to choose ranges that bear a 2 or 2½ to 1 ratio to each other, such as 1, 2, 5, 10, etc., or 1.5, 3, 7.5, 15, etc. By this choice, any calibration desired may be made with the standard reading 40% or more of full scale, with a corresponding effective error of not more than 2½ times the full-scale percent error. Of course, with complete calibration curves being employed on the standard, this accuracy may be exceeded.

A fifth need is for means by which the ranges of the standard instruments and power supply levels may be quickly chosen and connected. This may be done by providing terminals on a panel, with connecting leads for the standards and the same for the power supplies. A further refinement is the grouping of the standard terminals in relation to the power supply terminals with which they may safely be used. For example, the arrangement might group the 100-, 200- and 500-volt instrument ranges around the 100-volt power supply in order to indicate that they should be used with higher-voltage power supplies only with great caution. This precaution is quite effective in reducing the possibility of damage to the standards.

Sixth, controls of voltage and current should be so fine that the instruments may be set exactly on any scale reading. This may be accomplished by using a line voltage coarse control, 0-115 volts; a medium control, 0-10 or 15 volts; and a fine control, 0-1 or 2 volts. The outputs may be connected in cascade and will give perfectly satisfactory control of the power supplies. Fig. 3 shows a method of accomplishing this.

Seventh, the a-c. power line feeding the above controls must be so well regulated that no detectable changes of voltage or current appear as a result of line surges. It may be necessary to cascade two voltage regulators in the power line, since a jump of one-half

percent, which may easily occur with one regulator, is entirely too great for anything but a rather coarse calibration.

Eighth, the power fed to the controls must be free of harmonics if the a.c. is to be used for calibrating a-c. instruments other than of the dynamometer or iron-vane type and is preferred also for them. The dependence of vacuum-tube voltmeters and rectifier type instruments upon wave shape is well known. If the voltage regulators used generate distortion or the power line should be bad to begin with, filters must be employed to reduce it to a suitable value, probably one percent or better.

The apparatus should be complete in itself, which means — in addition to some of the above detailed requirements —that all items needed for calibrating must be permanent parts in the system, that all wiring must be complete and permanent so that use of the system involves only the use of the regularly-furnished connecting leads on the panel, and the manipulating of controls, likewise on the panel.

A further refinement, involving the characteristics of the room in which the apparatus is to be used, is the maintenance of a reasonably uniform temperature and the avoidance of excessive humidity. The temperature requirement arises from the fact that the readings of the standards vary with temperature and may be considered correct only at the temperature at which they were calibrated. A multiplying factor, usually supplied by the maker of the instrument, must be used for other temperatures for good accuracy. The humidity requirement is a precaution to prevent insulation leakage in the instruments and wiring from causing errors. Under conditions of high humidity, leakage may cause unreasonable errors unless all insulation is carefully chosen to avoid such a situation.

The Value of a Calibrating Table

A calibrating table incorporating the features discussed above will prove to be an invaluable assistance to any organization which has a need for accuracy in its electrical indicating instruments. We are all familiar with the usual arrangement of standards with inadequate protection, non-permanent mounting, non-permanent and oftentimes unavailable power supplies, poor system of controls, if any, use of clip leads or other improvised wiring, and other chaotic arrangements that so often make the use of the standards an expensive luxury by reason of danger to them and time lost in making set-ups for each calibration.

The advantage of a system with the desirable refinements outlined will be apparent when it is pointed out that an instrument may be connected and calibrated at one scale reading in a half-minute, which includes choosing the desired standard instrument range and choosing the proper power supply. Without the calibrating table arrangement, the time would run a minimum of several minutes, even if everything is available. If something is missing, the delay will be indeterminate.

It should be pointed out that the cost of the entire system is already largely covered in the cost of the standards and all other components that are required even without the table. As an estimate, probably two-thirds of the expense is involved in the items already in use. The additional cost writes itself off in time saved within a few months if much calibrating is done. Proper use of the equipment by this means, together with the reliability and convenience which it provides, have an indefinite value.

Suggested Equipment

No two readers would independently produce instrument-calibrating apparatus of identical characteristics or arrangement. Such an apparatus is quite complex and must be an embodiment of a multitude of well-known principles for practical and efficient use. Since wide over-all choices may be made, it is to be expected that any two designs might be quite different.

For previously-published reports on the subject, readers may refer to back issues of *Instruments*, particularly to the following:

March, 1938, pages 93-95: "Equipment for Precision Calibration of Electrical Instruments," by W. D. Egnor, General Electric Co., Schenectady, N. Y. This article gives detailed information on the extensive permanent installation at the G. E. General Engineering Laboratory for calibration of secondary standards and special instruments. Two diagrams, six photographs.

July, 1940, pages 186-187, 197: "An Electrical-Instrument Calibrator," by Leslie E. Kulberg, Boston, Mass. This article describes an equipment for calibrating the class of instruments, including the panel type and the service type, where the accuracy of primary or secondary standards is not needed. A complete parts list is included. One highly detailed diagram, two photographs.

March, 1943, pages 116-120, 154: "A Versatile Table for Calibration of Electrical

Instruments," by John E. Warren, Bayside, L. I., N. Y. This article describes an instrument repair company's equipment, less elaborate than that described by W. D. Egnor of G. E. Five diagrams, seven photographs. Six references.

February, 1945, pages 74-76: "A Versatile Semi-portable Calibrating Bench for Electrical Instruments," by Mrs. N. M. Gilbert, Bell Telephone Laboratories, New York City. The bench described is especially suited to calibrating "testing instruments" used in the laboratory or in factory test departments where Primary Standards are not necessary. Five diagrams, three photographs.

July 1947, pages 613-615: "A Transportable Potentiometer Test Table for Instrument Calibration," by W. A. Castner, Measurements Corp., Boonton, N. J. Describes table for d.c. only. Three photographs, one full-page diagram.

The apparatus described in this article was designed to incorporate features which would satisfy, as completely as practicable, all the requirements we have discussed for an apparatus capable of the utmost precision for calibrating standard instruments and flexible and fast enough to use for routine calibration of "testing instruments." It is a calibrating table of particular value to users of instruments in industry. All routine calibrating is done by reference to the Standard instruments incorporated in the table. These Standards, in turn, are calibrated by use of the precision potentiometer and bank of standard cells. An external standard instrument or cell may be calibrated or may, in turn, be used as a standard without touching the permanent internal wiring of the apparatus.

Following is a list of some of the equipment used by the Farnsworth Television & Radio Corp. which may be found to be of value by any laboratory director or manufacturer in planning a calibrating table for his own use:

A. For Calibration of Standard Instruments

1. Leeds & Northrup Type K2 Potentiometer (0-1.6 volts d.c.).
2. Three Eppley (Leeds & Northrup) Standard Cells for above.
3. Leeds & Northrup Volt Box (Multiplier for Potentiometer to 750 v.).
4. Leeds & Northrup Volt Box (Multiplier for Potentiometer to 5 kv.).
5. Leeds & Northrup Shunt (Multiplier to 7.5 amps.).
6. Leeds & Northrup 2500-G Galvanometer (for Potentiometer & Bridge).
7. Rubicon 3402H Galvanometer (for Potentiometer & Bridge).

B. Standard Instruments for Direct Voltages

1. Weston Model 5 Voltmeter (3- to 300-volt ranges).
2. Two Weston Type 2-1 Multipliers (750 v. to 1.5 kv.).
3. Two Weston Type 2-3 Multipliers (3 and 6 kv.).

C. Standard Instruments for Direct Current

1. Weston Model 622 Milliammeter (30 μa. to 15 ma.).
2. Weston Model 5 Ammeter (100 millivolts).
3. Ten Precision Shunts for above (30 ma. to 30 amps.).

D. Standard Instruments for Alternating and Direct Voltages

1. Weston Model 341 Voltmeter (1.5 and 3 v. a.c. and d.c.).
2. Weston Model 341 Voltmeter (7.5, 15 and 30 v. a.c. and d.c.).
3. Weston Model 326 Voltmeter (75 to 300 v. a.c. and d.c.).
4. Weston Model 311 Potential Trans. for above (600 v. a.c.).
5. Weston Model 311 Potential Trans. for above (1.5 and 3 kv. a.c.).
6. Weston Model 311 Potential Trans. for above (4.5 and 9 kv. a.c.).

E. Standard Instruments for Alternating and Direct Current

1. Weston Model 370 Ammeter (250 and 500 ma. a.c. and d.c.).
2. Weston Model 370 Ammeter (1 and 2 amps a.c. and d.c.).
3. Weston Model 326 Ammeter (5 amps. a.c. and d.c.).
4. Weston Model 327 Current Trans. (10 to 50 amps. a.c.).

F. For Checking the Potentiometer

1. Leeds & Northrup No. 4725 Wheatstone Bridge.
2. Leeds & Northrup Bureau of Standards Resistors of 1, 10, 100, 1,000 and 10,000 ohms.

G. Power Supplies

1. D-c. Volts—1, 10, 100, 1 kv, and 10 kv.
2. Direct Current—100 μa., 1, 10, and 100 ma., 1 amp.
3. A-c. Volts—1, 10, 100, 1 kv, and 10 kv.
4. Alternating Current—250 ma., 1, 5, 10, and 50 amps.

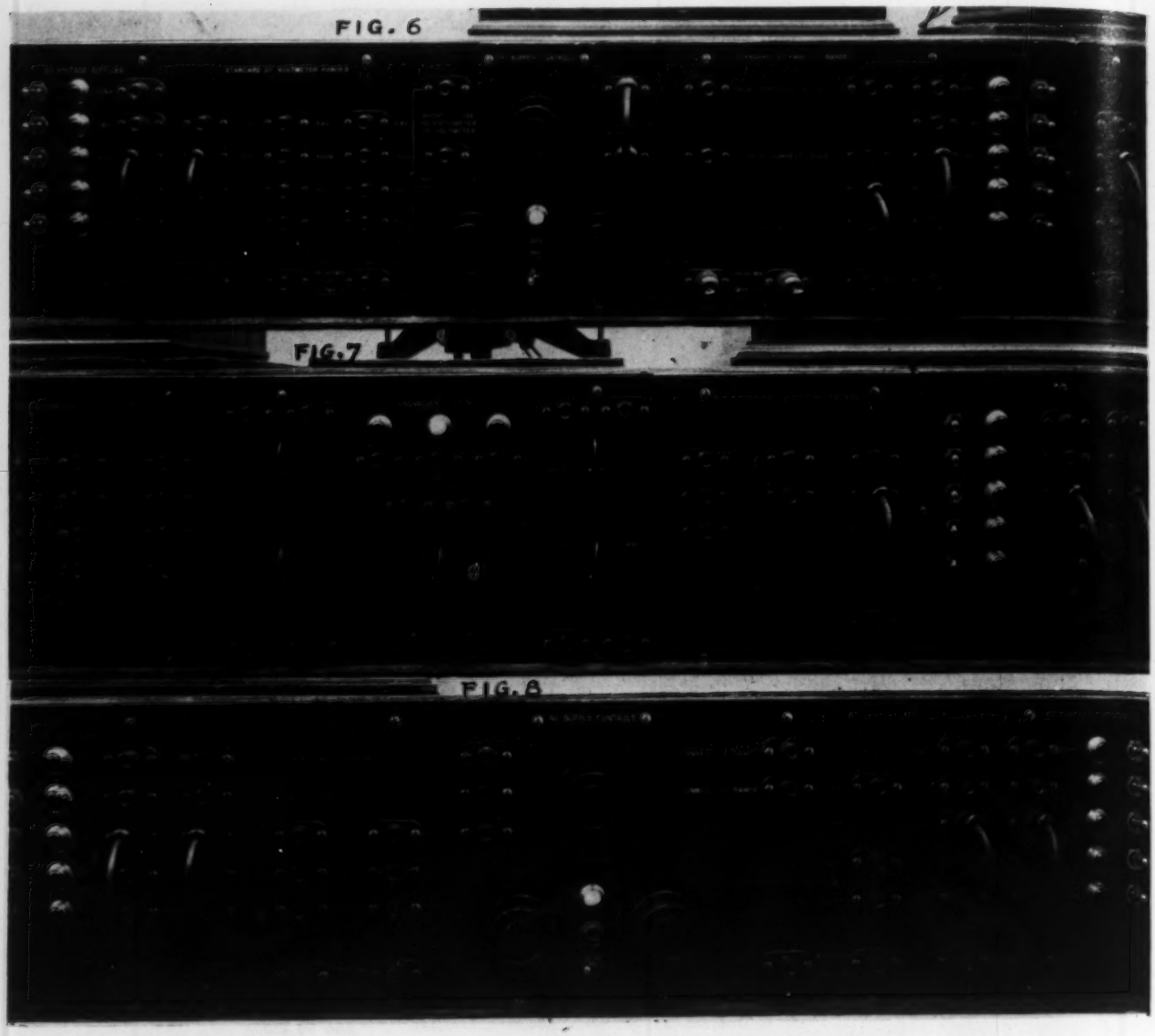
System Arrangement

Figs. 4 to 8 show the table designed and assembled by Farnsworth, using the above equipment and incorporating the features discussed. The details of the arrangement by which it conforms to the desirable features are as follows:

First, for physical protection the standards are installed in the glass-topped table shown in Fig. 4. The front opens outward in the upper compartment and the top lifts. Thus, the standards are protected and are permanently positioned, yet are highly accessible. Fig. 5 shows the table open. The felt pads cushioning the instruments may be seen.

Second, electrical protection is furnished by the use of power supplies with limited voltage and current capacity to prevent damaging the standards.

Third, for calibrating the standard instruments, panel connections and controls are available for connecting the potentiometer into the direct current and voltage circuits. Fig. 6 shows the d-c. panel and the terminals for connecting the potentiometer. Fig. 7 shows the panel used to control the potentiom-



eter, including switches for selecting the standard cell in use, the galvanometer in use, connecting the galvanometer to the potentiometer, choosing voltage or current arrangements, and galvanometer sensitivity. External connections also are made to connect the storage cell to the potentiometer. Other functions of the panel involve use of the Wheatstone bridge and connecting the galvanometer to an external bolometer not used in instrument calibrating. Calibration of the a-c.-d-c. instruments, Fig. 8, is accomplished by connecting them as unknowns with long leads to the d-c. panel. This table is not designed to calibrate wattmeters, but slight modifications could be made to provide for this if desired.

Fourth, to permit reading the standards at reasonably high scale readings for all values, the large number of ranges chosen for the standards gives 40% or greater of full-scale for any value.

Fifth, speed and convenience of connection to the various standard ranges and power supplies is provided by the terminals and connecting leads shown. To clarify the circuit arrangements, the d-c. and a-c. panels are engraved to show the circuits used. Examination of these panel layouts will reveal the real simplicity of the system.

Sixth, the controls of voltage and current level as seen on these panel layouts are conveniently grouped for speed of operation and give such fine control that the smallest increment of control cannot be detected on the standards, assuring that the instruments can be set as precisely as desired.

Seventh, excellent stability of voltages and current is obtained by cascading two regulators. The most severe line surges, due to starting electric motors, are just barely detectable on the potentiometer circuit and do not perceptibly move the standard instruments. This prevents one of the biggest headaches in calibrating.

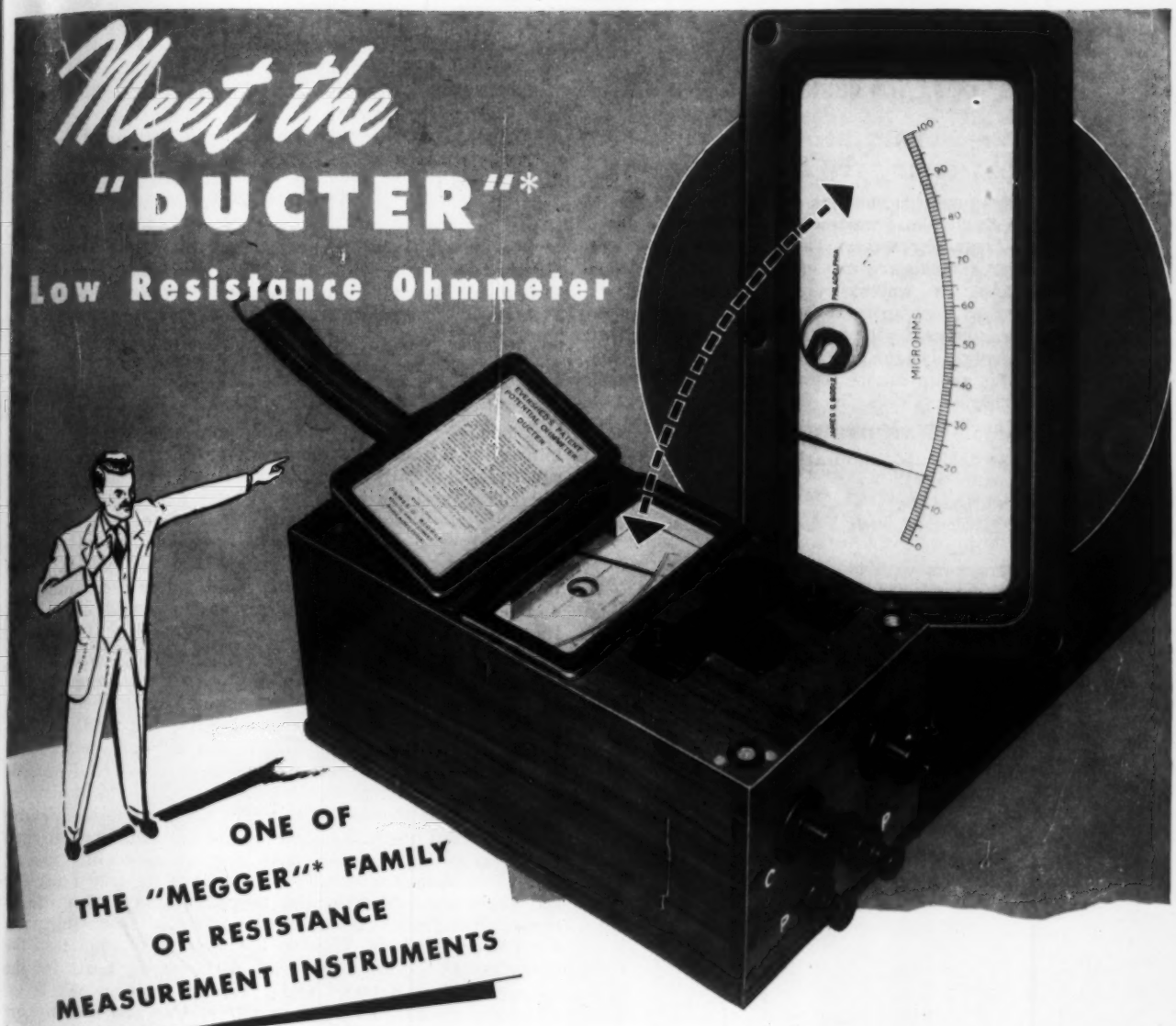
Eighth, the wave-form for a-c. calibrations is purified by a special filter in the power line so that vacuum-tube voltmeters and rectifier type instruments may be calibrated with suitable accuracy.

Finally, the table is a complete unit. Everything required for the job of calibrating is included in the permanent installation. The instrument to be calibrated is connected with a pair of leads furnished for the purpose, as in Fig. 4; the power supply is selected by means of the flexible connector, as in Fig. 6; and the standard instrument is selected in the same manner. Then the power supply switch is thrown on, the main switch is thrown on and the controls are turned up. A reading may be made in a few seconds and there is never a delay due to difficulty in connecting the equipment.

The arrangement described in this article has been found to be a vast improvement over the more usual uncoördinated temporary arrangement and has met with enthusiasm and approval from the individuals who have occasion to use it or observe its use. Any group which already has acquired the standards and associated equipment for their needs will be more than rewarded for their efforts if a suitable permanent arrangement is made for their use.

Meet the "DUCTER"*

Low Resistance Ohmmeter



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MEASUREMENT INSTRUMENTS

Rugged, accurate and direct-reading, the "Ducter" Low Resistance Ohmmeter provides an easy and practical way to test air and oil circuit breaker connections and contacts; cable joints; bus bar and line connections; armatures and series fields of generators, and motors; and low resistance transformer windings. It is also a valuable tool in quality control and for indicating relative strength and conductivity of welded joints.

One man can quickly make resistance measurements down to a millionth of an ohm—in the field! There are no calibrations or adjustments—not even for the voltage of the battery that supplies the necessary test current—and there are no calculations or charts. The resistance measurement is read directly from the position of the pointer on a scale.

The "Ducter" operates from an external battery or plug-in power supply. On every range it is compensated for outside temperature changes. As a protective feature a cut-out is included in the circuit to prevent application of too high voltage, and very high resistances or open circuits.

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Operation *and* Care *of* Circular-scale Instruments

By JAMES SPENCER, Meter Division, Westinghouse Electric Corp., Newark, N. J.

PART III

ELECTRODYNAMIC TYPE INSTRUMENTS

Electrodynamic type instruments of the circular-scale line includes the single-phase wattmeter, the polyphase wattmeter and the frequency meter. These instruments have been designed for switchboard use on a-c. circuits of commercial frequencies. The wattmeters are made in self-contained units with ratings up to 25 amperes and 250 volts. Frequency meters are used with external reactors (as shown in Fig. 19). Although designed for use on a-c. circuits, the wattmeters of this group can be used on d-c. circuits with reasonable accuracy.

WATTMETERS

For general switchboard application, the circular-scale wattmeters are made as:

Single-phase wattmeters.

Single-phase wattmeters with Y-box for 3-phase 3-wire balanced loads.

Polyphase wattmeters with two current coils.

Polyphase wattmeters with three current coils.

These long-scale type instruments combine the desirable features of simplicity of construction, ease of adjustment, high degree of sensitivity and a long scale with small space requirements.

Owing to the heavy shielding of these instruments, they can be used with equal accuracy on either steel or non-magnetic panels.

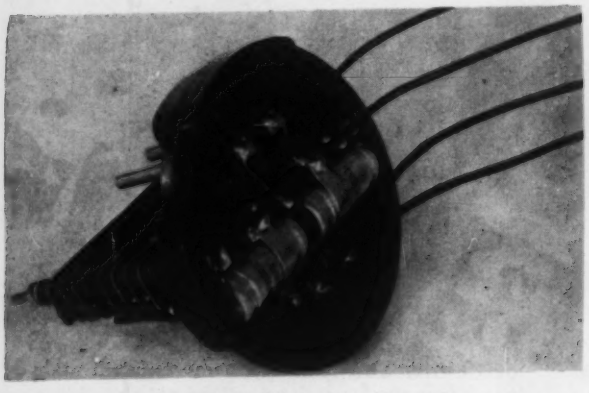

Fig. 1. Base assembly for Westinghouse KF-24 polyphase wattmeter.

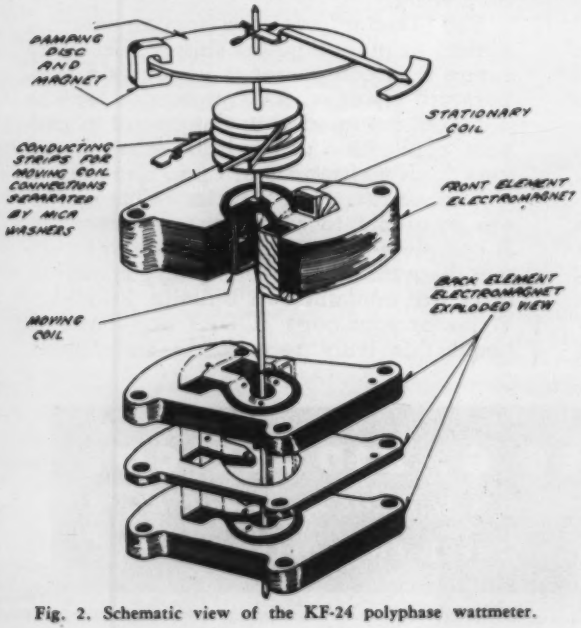
DAMPING DISC AND MAGNET
STATIONARY COIL
CONDUCTING STRIPS FOR MOVING COIL CONNECTIONS SEPARATED BY MICA WASHERS
FRONT ELEMENT ELECTROMAGNET
BACK ELEMENT ELECTROMAGNET EXPLODED VIEW
MOVING COIL

Fig. 2. Schematic view of the KF-24 polyphase wattmeter.

CONSTRUCTION

The circular-scale, KF-24 wattmeter, in general, consists of five principal parts, namely the base assembly, electromagnet, moving element, mechanism and case. As an aid to instrument people in caring for and servicing these parts, the following assembly details are offered.

The *bases* of the wattmeters, both single-phase and polyphase, are similar except for the extra terminals and details to cover two elements instead of one. The base assembly (see Fig. 1) in general consists of the molded base, capacitors mounted in the inner side, potential connection terminals, provisions for mounting studs, external resistor cards, resistor card mounting posts and resistor cover. The capacitors, resistor cards, cover and mounting studs are assembled in a similar manner to those of the a-c. voltmeter. All other details of the base assembly are similar to the assembly of the a-c. ammeters and voltmeters. Since this phase of assembly was covered under a-c. ammeters and voltmeters, any further discussion would only be a repetition.

The polyphase *electromagnet assembly* as shown in Figs. 2 and 3 consists of the upper and lower electromagnet, connector block, frame, series coil terminals, mounting studs and necessary hardware for assembling the unit. The assembly of this unit is so simple that a ⅜" open-end wrench and a screwdriver are the only tools required to dismantle or assemble the complete electromagnet. The mechanism-to-base mounting studs also serve to hold the lower electromagnet to the frame. The holes in the electromagnet through which the lower studs pass have insulating sleevings and an insulation washer is placed at each end of the sleevings. The studs are assembled to the tapped frame and protrude through the frame sufficiently to be used as mounting posts for the upper studs. The top assembly is the same as the lower except the top studs serve as mounting posts for the connector block support plate. The connector block is attached to the support plate by two screws and the support plate is held tight by hex nuts on the top of each mounting stud.

The single-phase wattmeter electromagnet assembly is similar to the lower half of the polyphase assembly.

The electromagnet assembly is attached to the base by the four lower mounting studs and held fast by hex nuts, one on each stud. The series coil terminals are inserted in the base holes provided for them and are made tight by lock washers and nuts. Connections are then made from the connection block of the electromagnet to the potential terminals in the base.

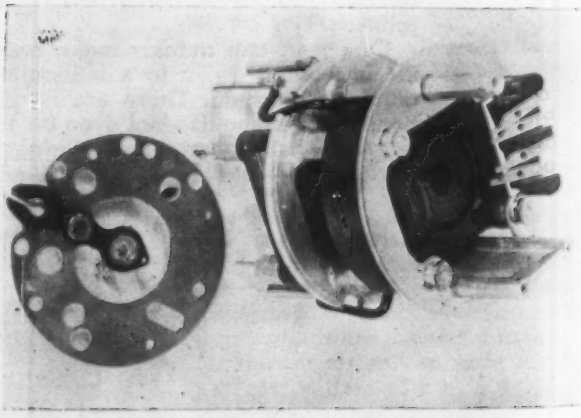

Fig. 3. Stator assembly of KF-24 polyphase wattmeter.

The *moving element* of the circular-scale 3-phase wattmeter consists of a progressive assembly of the various parts on a stainless steel shaft pivoted at both ends with hard steel pivots. The shaft is knurled at carefully determined points to grip the press fit parts assembled to the shaft. The element as shown in Fig. 4 is assembled as follows: The lower bumper is pressed on the shaft, after which the lower bracket for the rear coil is assembled. A piece of insulation tubing is cemented in place on the shaft between the brackets of the rear coils. The upper bracket for the rear coil and the lower bracket for the front coil are next pressed into position. A second piece of insulation tubing is placed and cemented to the shaft before the upper bracket of the front coil is pressed into position. The springs as assembled on the shaft are separated by molded bushings and mica disks. All parts are so designed that they fit together in a tongue-and-groove method and the springs are positioned so that the front two close in a clockwise direction and the back two, counterclockwise. The counterbalance weight arm is next pressed in position, after which the damping disk, control spring, and pointer assembly are positioned. The top bumper is the last item pressed on the shaft and its position is determined by a slight shoulder on the shaft against which it butts.

The coils are assembled in the cement-prepared coil brackets. After the cement is thoroughly dried, the long tails of the spring collets are insulated with tubing, insulated leads from the collets to the coils are connected (soldered) and the pigtails from the coils are soldered to these leads.

The pointer, control spring, and damping disk assembly is a bushing-staked arrangement that also includes crossarms and balance weights.

In assembling the element in the electromagnet (see Figs. 2 and 3) the operator will experience little difficulty if the following procedure is carefully applied:

1. With the instrument in the face-up position, lower the rear coil through the slot in the core of the front electromagnet.
2. Rotate the element clockwise approximately three-fourths turn until coil drops through second slot.
3. Rotate element counterclockwise three-fourths turn and lower.
4. Rotate element clockwise three-fourths turn and lower.
5. Rotate element counterclockwise approximately one-third and lower.
6. Rotate element clockwise three-fourths turn and lower.

During the complete operation the element should be kept in a vertical position and rotated slowly and carefully to avoid damaging the coil by rubbing on the edges of the iron laminations.

To dismantle, reverse the assembly procedure.

To complete the mechanism, Fig. 5, the top bridge plate assembly is attached, the element shaft is set and adjusted

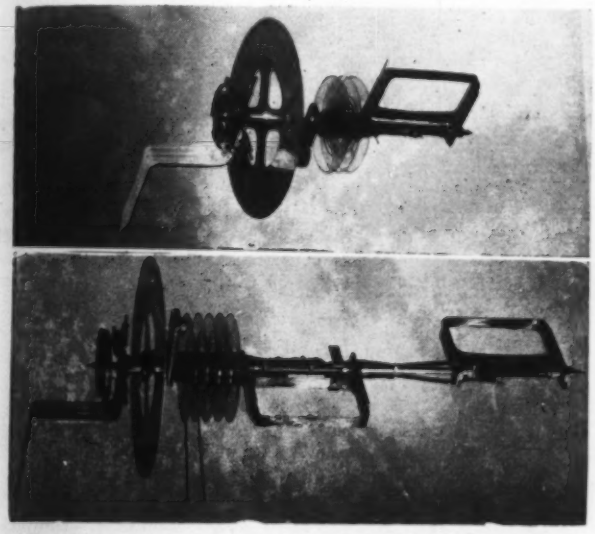

Fig. 4. Moving element assemblies of the K-24 single-phase and polyphase wattmeters.

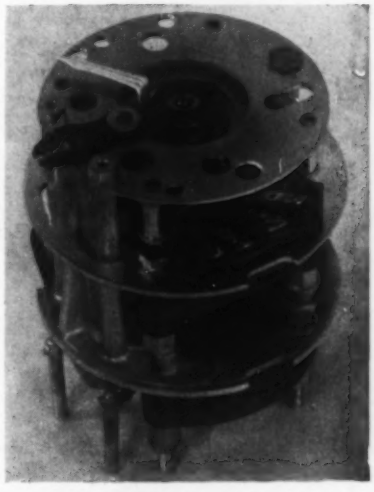

Fig. 5. KF-24 polyphase wattmeter mechanism.

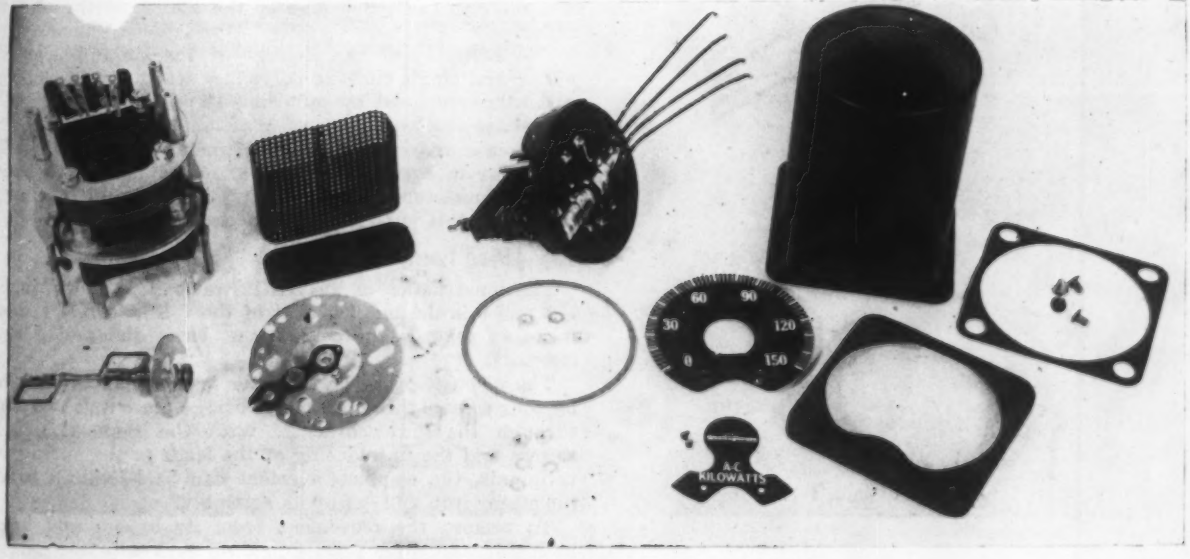

Fig. 6. The parts of a Westinghouse KF-24 polyphase wattmeter.

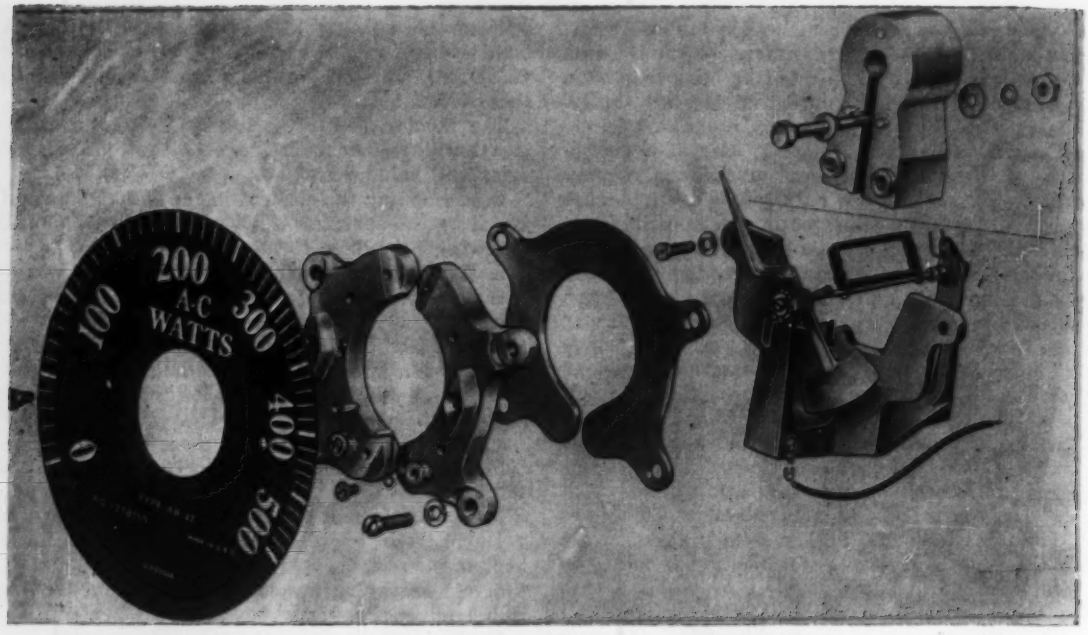

Fig. 7. Exploded view of General Electric AB-12 single-phase wattmeter.

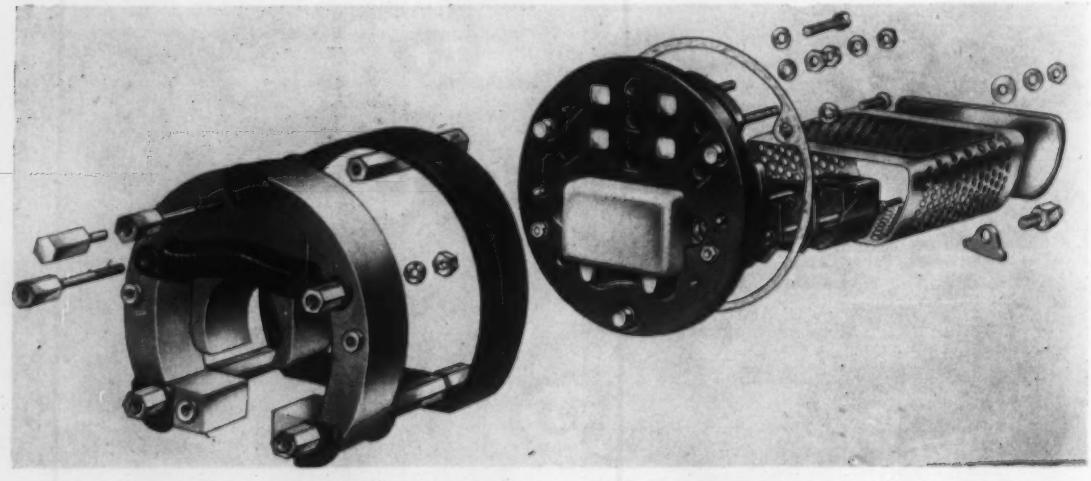

Fig. 8. Exploded view of G-E AB-12 single-phase wattmeter.

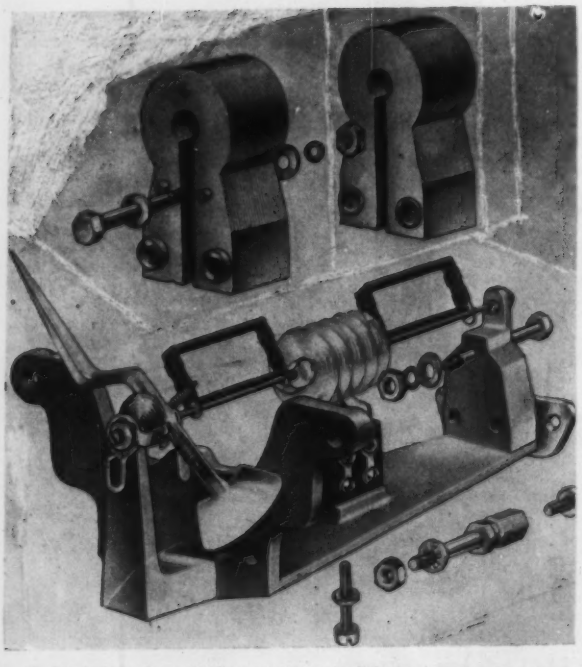

Fig. 9. Exploded view of General Electric AB-12 polyphase wattmeter.

between the jewels, and the springs are anchored (conducting spring to connector block and control spring to zero adjuster clamp). The top bridge assembly of the wattmeter is similar to the top bridge of the a-c. ammeter and voltmeter.

The assembly of the element of the single-phase wattmeter and single-element polyphase wattmeter can be successfully completed by following steps one and two of the polyphase outline.

The case and cover of the wattmeter as shown in Fig. 6 is similar in construction and assembly details as that of the a-c. ammeters and voltmeters, therefore no further discussion of this part should be necessary.

The AB-12 Wattmeters

The construction of the AB-12 wattmeters shown in Figs. 7, 8 and 9 is the same as that of the voltmeters of the same make as regards the cover, case, base, dial and damping magnets.

The *element* of this wattmeter is attached to the stator by four screws through the top bridge plate and two screws through the lower bracket. With the removal of these screws and the unsoldering of the leads to the spring block terminals, the complete element can be lifted up to clear the stator iron and out of its assembly.

To remove the movement from its bridge and bracket assembly, the three screws holding each core to the frame must be removed and the core carefully slid out of the

Fig. 10. Rear view of G-E AB-12 wattmeter.

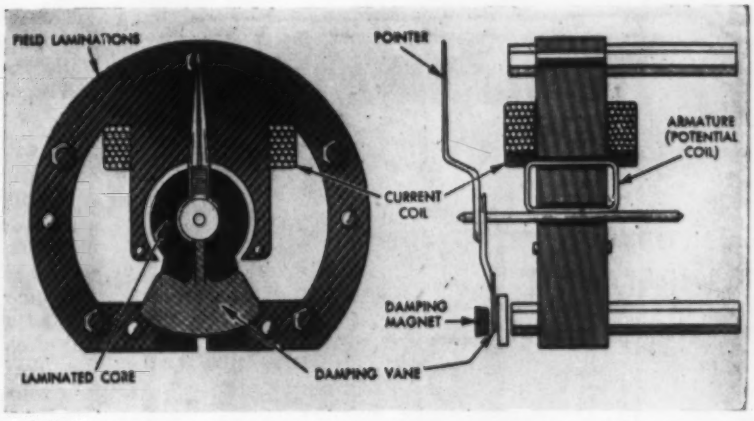

Fig. 11. Showing in diagrammatic form the mechanism of the G-E AB-12 wattmeter.

moving coil. The spring (conducting and control) must be loosened from their anchors, the jewel screws opened and the element removed from between its jewels.

The stationary coils are prewound and are positioned by finger-type clamps bolted to the field laminations.

With the instrument dismantled to this point, the remaining operations of dismantling are obvious.

Single-phase wattmeters of this type follow the same general construction as the d-c. instruments of this same make except that the permanent magnet is replaced by the electromagnet.

Connections

The line connections of two-current-coil polyphase wattmeters are shown in Figs. 12, 13 and 14. Connections are conventional: current coils in series and potential coils in parallel with the circuit to be measured.

Principle of Operation

The wattmeters operate on the electrodynamic principle. This movement depends for its operation on the interaction of the fields of at least two coils. One coil is stationary and one is movable; the travel of the moving coil is spring-controlled as it tends to move in a direction where the fields of the two coils will align themselves. The current in the stationary coil produces a field in proportion to the current flow. As a current is applied to the moving coil, the coil moves by virtue of the reaction of a current-carrying conductor in a magnetic field. Since the fields of the stationary and moving coils are proportional to the current in them, and since the moving coil moves in the field of the stationary coil, the torque of the moving coil is proportional to the product of the currents in the stationary and moving coil times power factor. This accounts for the practically even scale distribution of these instruments. A forward movement of the pointer depends on the relative polarity of the stationary and moving coils.

The controlling force of the KF-24 instrument is produced by the action of a spiral spring mounted on the movement shaft, with its outer end clamped in the zero adjuster arm. The other springs in this instrument are of low torque and are designed only for the purpose of conducting current to and from the moving coil. The electromagnetic damping of this instrument is produced by action of an aluminum disk moving in the fields of two permanent magnets. The permanent-magnet field strength is adjusted at the factory to achieve the desired damping effect.

The high torque developed and the low energy consumption of this type of instrument are the result of the electromagnet assembly used to increase the permeability of the field of the stationary and moving coils. The laminated soft-iron electromagnet is so arranged that it produces a uniform air gap in the area of coil rotation.

Ordinarily, the introduction of iron in an instrument circuit causes effective power factor and frequency errors. In this instrument, however, it has been possible to minimize these errors and get a good accuracy on d-c. and a-c. circuits of commercial frequencies. These desirable characteristics may be attributed to the careful design of the electric and magnetic circuits.

These wattmeters are designed primarily for a-c. measurements, but may be used for d-c. measurements as the accuracy difference of a-c. and d-c. is relatively small; for best accuracy on d-c., the self-contained rating of the instrument should not be exceeded, the slight difference being due to residual in the iron of the circuit. On a-c., the currents may be out of phase to some extent and the forward torque will be produced only by the in-phase components, giving a true watt reading when connected to a circuit correctly.

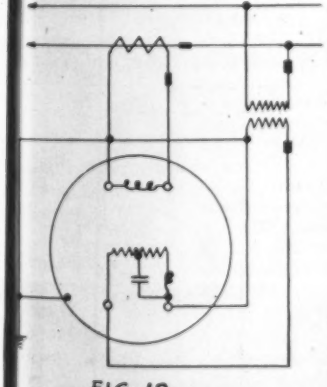

FIG. 12. SINGLE-PHASE WATTMETER CONNECTIONS

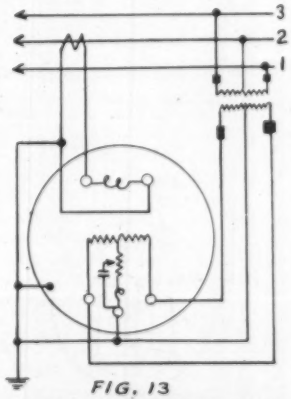

FIG. 13 SINGLE-ELEMENT WATTMETER WITH Y-BOX CONNECTIONS FOR 3-PHASE BALANCED LOADS

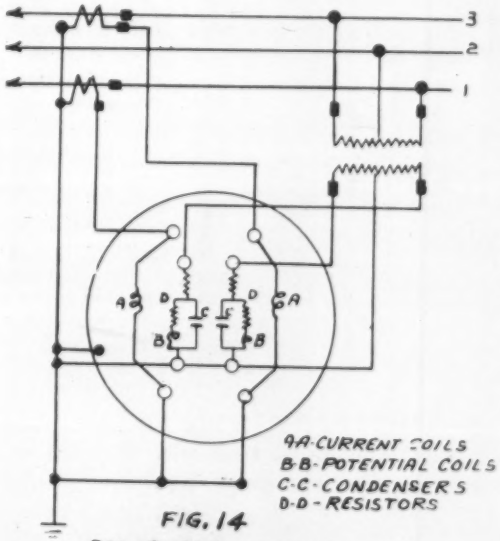

FIG. 14 POLYPHASE WATTMETER CONNECTIONS

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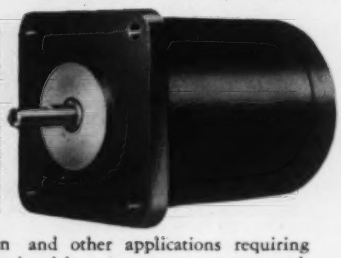

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The AB-12 concentric-scale wattmeter shown in Figs. 7 and 8 also operates on the electrodynamic principle and while the two instruments described differ in appearance and construction, they are alike in their operating principle.

Calibration and Inspection

As with all electrical measuring instruments, before any calibration adjustments are made, a complete mechanical inspection is made. This inspection includes tightening all screws and nuts, checking all solder connections for contact and appearance, checking all manually-operated parts such as zero adjuster, etc., and, last but not least, seeing that the instrument is perfectly clean. Balance should be checked and adjusted if necessary, using the balance weight on the tail-piece and cross-arms for this purpose as outlined under d-c. instruments. End play check and adjustments may also be covered as explained under d-c. instruments.

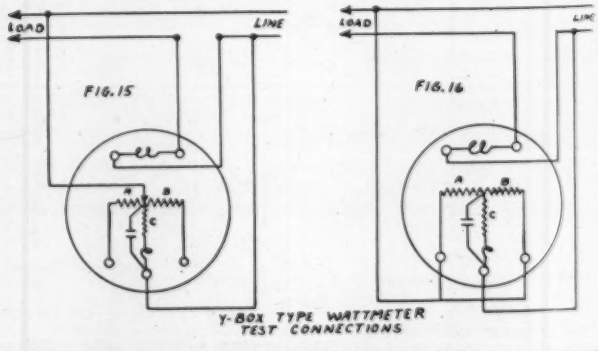
After mechanical inspection and adjustments are made, the instrument should be connected to a test circuit and checked for polarity. This test is to ascertain that the instrument gives a positive indication when connected as shown in the wiring diagram Figs. 12, 13 and 14. With this same connection, friction can be checked by varying the voltage or current so that the pointer moves up and down scale slowly. During this test, the pointer should be stopped at several points, the position noted and the instrument tapped to see if pointer shift takes place. A shift of the pointer when the instrument is tapped indicates friction.

Single-phase Wattmeter

With the wattmeter connected to a 60-cycle test circuit, adjust the series resistance to get approximately full-scale deflection. This test should be made at unity power factor with rated voltage and watts. The capacitor is then connected across approximately half the external resistance and the moving coils as a trial setting. The resistance in parallel with the capacitor and the series resistance should be adjusted until the instrument indicates half-scale at both unity and fifty percent power factor when half load is applied at rated voltage. Full-scale calibration is then made at unity power factor by readjusting the resistance in series with the capacitor circuit. A convenient method of making this test is by using two variable resistors such as resistance decade boxes and, when calibration is complete, adjusting the permanent resistance to the value of the boxes.

All main calibration points should be checked by varying the load and comparing the readings of the instrument under test with those of a standard of known accuracy.

The single-element wattmeter with the Y-box connection is shown in Figs. 15 and 16. This instrument is calibrated the same as the single-phase standard instrument except for the adjustment of the resistors *A*, *B* and *C* in Figs. 15 and 16. With the instrument connected to the test circuit as shown in Fig. 15, apply two-thirds rated load at two-thirds rated voltage and adjust resistor *C* to give a full scale deflection of the pointer. Resistors *A* and *B* should then be adjusted so that each has the same resistance value as resistor *C*, plus the element. Resistors *A* and *B* should be equal within ½% of each other. The instrument should then be connected as in Fig. 16, full load applied and full scale point checked. Final adjustment of full scale may be made by adjusting resistors *A* and *B* by equal amounts.



Figs. 15 and 16. Connections to be used in calibrating Y-box type wattmeters

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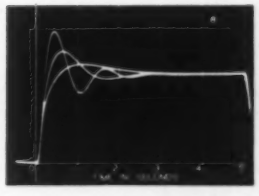

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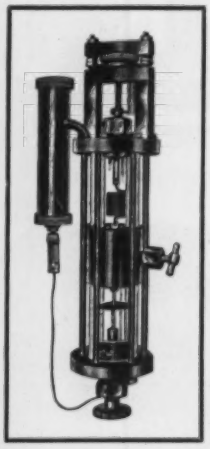

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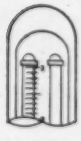

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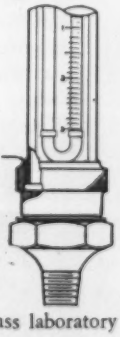

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Polyphase wattmeters as shown in Fig. 14 may be calibrated on single-phase, each element being adjusted separately as outlined for the single-phase instrument. The voltage coils of both elements should be energized at rated voltage during all tests, with full load applied at unity power factor, each element separately should indicate half scale, with both elements energized, the pointer should deflect to full scale. The half-load point for compensating at unity and 50 percent power factor is at approximately one-quarter scale.

On both the single-phase and the polyphase wattmeters, the control spring may be adjusted to correct slight errors of calibration if the error is uniform throughout scale. When the instrument leaves the factory, there is from one-fourth to three-eighths of a turn of spring available for this adjustment.

In addition to the inspection and test procedure as outlined, the concentric-scale instruments have an internal resistance spool in series with each element for final adjustments or corrections.

To correct distribution errors in the DB-12 wattmeters, (that is, low on one side and high on the other) the core-to-frame screws can be loosened and the core shifted to the side reading low. If this adjustment is made, be sure the core-to-frame screws are tightened before final checking of the instrument. If readings are in error throughout the scale and in the same direction (that is, all high or all low) the resistance cards on the back of the instrument can be adjusted to correct.

Maintenance of KF-24 and AB-12 Instruments

Let us consider the possible troubles encountered by an instrument service man. In instruments of the past, possibilities of trouble were many as compared with those of the new circular-scale instruments. Improved designs, simplicity, and ruggedness of construction, improved materials and ease of adjustment are just a few of the qualities that make these instruments relatively easy units to maintain and service. Accidental causes, misapplications, and rough handling do cause defects, however, even in the best of instruments.

Overloads for example, could result in burned-out coils, springs, or series resistance. A burned-out moving coil can be replaced as follows. Remove the element as outlined under "Construction." The coil is assembled and cemented between two channel type brackets. Acetone will loosen the cement and the coil can then be removed from the brackets. Before removing the coil, however, make an accurate check of the position of the coil to be sure of replacing the new coil in the same location. To replace a coil, brush a sufficient amount of household cement in the coil brackets to hold the coil, assemble the coil and connect the pigtails of the coil to the leads connected to the conducting springs. After this operation some aging or drying process should be applied to stabilize the assembly.

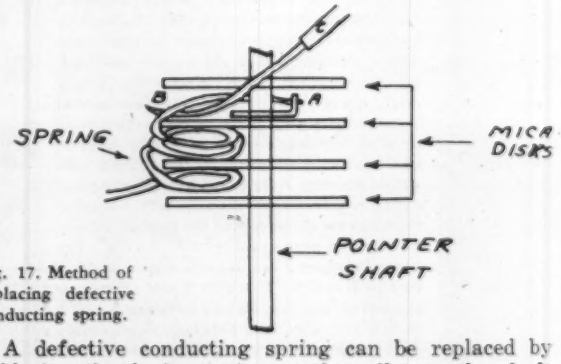

Fig. 17. Method of replacing defective conducting spring.

A defective conducting spring can be replaced by unsoldering the faulty spring at the collet on the shaft and soldering the inside end of a new spring to the assembled collet. One method of assembling and soldering the spring between the mica disks is to grip the inner end of the spring with a hook-shaped pair of tweezers and carefully separate the spring convolutions as shown in Fig. 17. With the spring in this position, solder the inner free end of the spring to the spring collet at *A*. When installing a new

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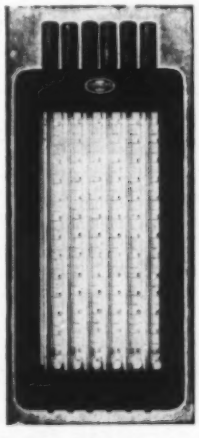

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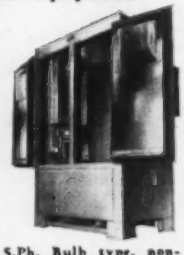

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spring, be sure it is assembled the same as the one displaced as the springs are arranged so that two open and two close as the element turns. After the spring is soldered to the collet, a hook shaped needle *C*, should be looped under the spring as at *B* and the needle gradually circled about the disk until the spring is pulled into place. Owing to the limited space between the disks, a pencil soldering tool is suggested for soldering the inner convolution of the spring to the spring to the collet.

If the series resistance is open owing to an overload, examine all resistor cards in the circuit and eliminate any that show signs of an actual burn-out or are badly charred. New cards should be installed and the instrument recalibrated.

If an instrument is open for repairs and fails to operate or operates incorrectly, a few of the possible causes to explore are:

Friction, sticking, opens, short circuits, balance, zero sets and no external-circuit potential.

Probably the first thing to check when an instrument fails to operate is the external circuit. Before opening the instrument and searching for defects, check the circuit being measured to ascertain that fuses and connections are not faulty and that there is voltage at the terminals.

Failure of an instrument to indicate might also be due to open circuits or short circuits. A few points to check for open circuits would be resistor cards, connections from cards through connector pins to base, conducting springs, coils, and connections (both soldered and mechanical). An ohmmeter can be used to check when the instrument is not energized or, if energized, a low-wattage lamp or a voltmeter might be used. The circuit should be checked in sections, that is, from the terminal to the element side of the resistance, then to the spring connector block, and finally from the block to the external terminal connection. The section in which the open is found should then be further divided until the exact point of the fault is found. A completely short-circuited moving coil would also result in a failure of indication and might be caused by two conducting springs touching, a short circuit between the connecting leads to the element, or the coil short circuited at its start and finish point. One means of detecting short-circuited coils is: With voltage applied to the instrument terminals, check the voltage drop across the anchor points on the connection block. If there is no indication, the coil is short-circuited either in itself or by the leads or spring leading to it.

Defective balance will cause a change in scale distribution; for example, if an instrument reads high on the upper part of the scale and low on the lower part of the scale, the balance weight in the tail-piece has probably shifted in the direction of the pivot. If the balance weight shifted away from the pivot, the calibration effect would be a lower indication on the high side and a higher indication on the low side of the scale. By this line of reasoning, it can readily be seen that any shifts of the side weights would also have an effect on the scale distribution of the instrument.

If an instrument indicates a constant percentage high or low throughout the scale, the instrument should be deenergized and the zero setting checked. In the circular-scale instruments, zero may be set or reset from the outside of the instrument by merely turning (with a screw driver) the zero adjuster in the front cover of the instrument.

Friction and sticking are the two most troublesome faults in any instrument. While the circular-scale instrument (owing to design, greater stability of materials and ruggedness) is not as susceptible to this fault as other instruments, errors of this nature do sometimes present themselves. If friction or sticking are present after working on a wattmeter, a few of the general points to check are listed below.

1. Pointer sticking on bumpers.
2. Pointer touching dial.
3. Pointer rubbing on spring clamp or adjuster arm.
4. Spring convolutions touching.
5. Springs touching mica disks.

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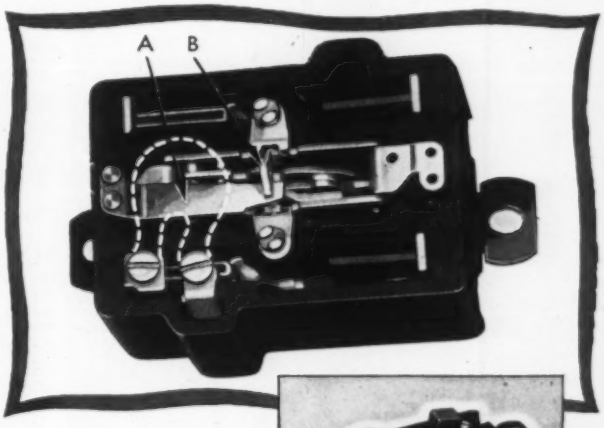

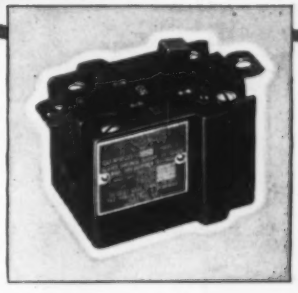

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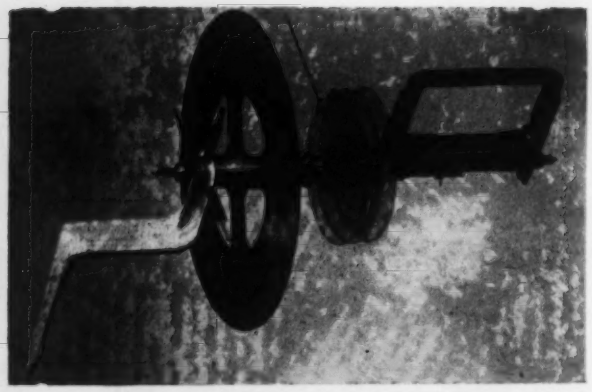

Fig. 18. Moving element of a Westinghouse KF-24 frequency meter.

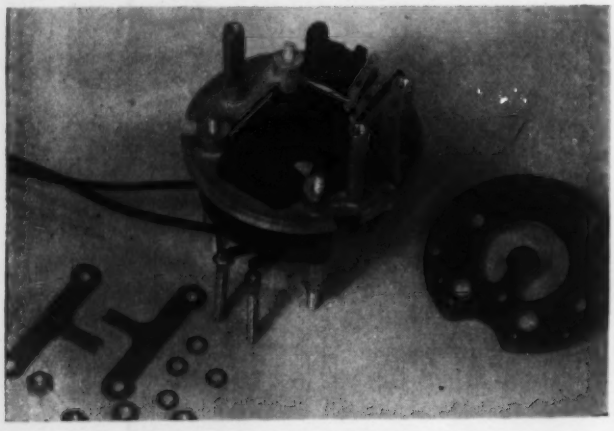

Fig. 19. Stator assembly of a KF-24 Westinghouse frequency meter.

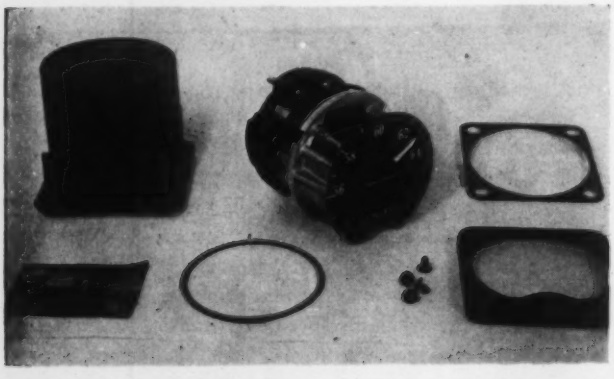

Fig. 20. Westinghouse KF-24 frequency meter with case and cover removed.

6. Damping disk touching magnet or other adjacent parts.
7. Balance weights touching spring clamp (balance arms bent).
8. Coils rubbing on electromagnet iron.
9. Excessive end play (element angulates and drags on adjacent parts).
10. Insufficient end play (tight between jewels).
11. Defective pivots or jewels.
12. Foreign material on damping disk scraping magnets.

Frequency Meters

Construction

The construction of the KF-24 circular scale frequency meter shown in Figs. 18-21 is practically the same as that of the single-phase wattmeter. The similarity is so marked that the instructions given for dismantling and reassembling the wattmeter can also be used for the frequency meter. The main difference between these two instruments is in the coil windings, the shape of the electromagnet core and bumper brackets mounted on the upper side of the electromagnet of the frequency meter. The core design of the frequency meter is such that it tapers down in steps from the start of the hook to the end of the hook. This allows the moving element to be assembled in position by threading the lower end of the coil directly through the slot in the core instead of the rotary operation as with the wattmeter.

The circular-scale frequency meter is used in conjunction with a capacitor-reactor unit as shown in Figs. 25 and 26. A steel base and cover completely shields the component parts of this unit. The construction of this capacitor-reactor is very simple, in fact all the parts are assembled to the base by bolt and nut method. The electrical parts of this unit are mounted on the base and wired as shown in Fig. 25. These parts include a step-down transformer, step-up transformer, a capacitor, an inductor, and a terminal block arrangement for internal-to-external connections. The steel cover is designed for clearance of the terminal block and is attached to the six base studs by filister head screws.

The AB-12 frequency meter shown in Figs. 22 and 23 is constructed similarly to the wattmeter shown in Figs. 6a and 6b. The similarity of construction being in the case, cover, damping vane and magnet, dial, base, element mounting and stator-assembly, all of which are dismantled as in the wattmeter of Figs. 7, 8 and 9. The element of this frequency meter consists of two parts, a moving coil and a moving vane, both mounted on the same shaft as shown in Figs. 22 and 23. The coil is mounted on the shaft similarly to that of a wattmeter element and the moving iron mounting is similar to that of the a-c. ammeter and voltmeter of this make. The element bracket is mounted in the stator assembly by four screws through the top of the bracket and the coil of the lower element is attached to the

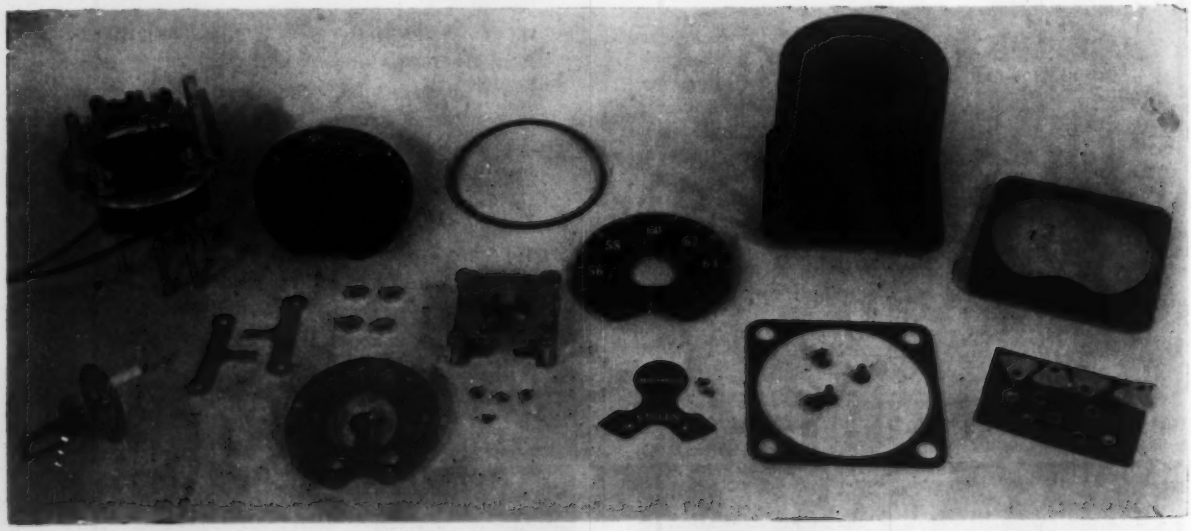

Fig. 21. Showing parts of a KF-24 frequency meter.

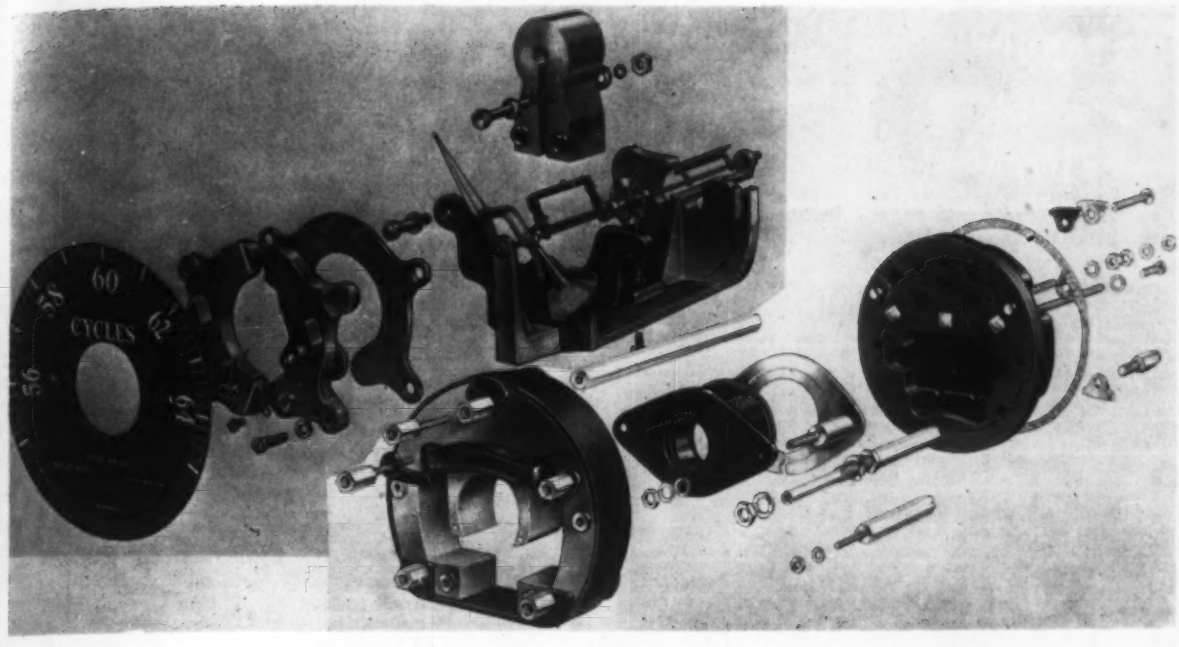

Fig. 22. Exploded view shows details of the AB-12 General Electric frequency meter.

bracket by two screws. The holes in the bracket through which the lower coil screws are inserted are elongated to allow for shifting of the coil.

The movement of this instrument is removed from the element bracket in a similar manner to that of the wattmeter of this make.

An external capacitor-reactor as shown in Fig. 23 is used with this instrument. This thermal capacitor-reactor consists of two groups of capacitors and a reactor having two windings, one on each outside leg of the reactor iron. An iron laminated bar is attached to a bracket that in turn is mounted on the main reactor iron. The mounting holes of this bracket are elongated to allow for shifting the iron with respect to the air gap of the reactor. The parts are all mounted and enclosed in an iron case.

Principle of Operation

The circular-scale KF-24 frequency meter operates on the well-known electrodynamic principle. This instrument differs from the conventional type however in that it includes an iron core arrangement for increasing the permeability of the field and allows for greater scale length.

The stationary coil is wound on the core arm of the electromagnet (Fig. 24) and, when energized by the line voltage, magnetizes the iron circuit. With the iron magnetized, there is a strong field across the full length of the air gap. The moving coil as shown in Fig. 24 acts as the secondary of a transformer taking its energy from the stationary coil. The moving coil and the network of reactance and capacitance are connected in series with an auxiliary coil (Fig. 25) that also serves as a booster to the moving coil.

In calibration, the moving-coil circuit is adjusted to be in resonance at 60 cycles with rated voltage. For other frequencies above or below 60 cycles, the position of the coil regulates the inductance of the circuit. This arrangement of constant resonance of moving coil circuit is due to the tapered design of the hook-shaped core. The width of the core stays constant, hence an even air gap throughout the full travel of the core, but the thickness gradually decreases from the start of the hook to the end. From this it will be seen that with a change in frequency, the coil changes its position and hence links either more or less iron, changing its inductance as required to maintain resonance. The step-up transformer tap arrangement is provided for calibration to take care of variations of capacitance.

The AB-12 meter shown in Figs. 22 and 23 operates on the electrodynamic resonant-circuit principle with a repulsion type movement for control. The deflecting unit is, in

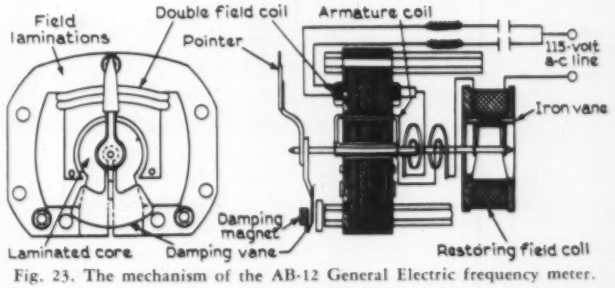

Fig. 23. The mechanism of the AB-12 General Electric frequency meter.

principle, a zero-center type wattmeter, less control springs. The repulsion movement is so arranged that the restoring torque is always in the direction of mid-scale. This characteristic is due to the shape of the stationary vane—tapering to narrowing width from both ends of the vane to the center.

An external capacitor reactor is used with this instrument and is connected as shown in Fig. 23. From the connection diagram it will be seen that a split-phase arrange-

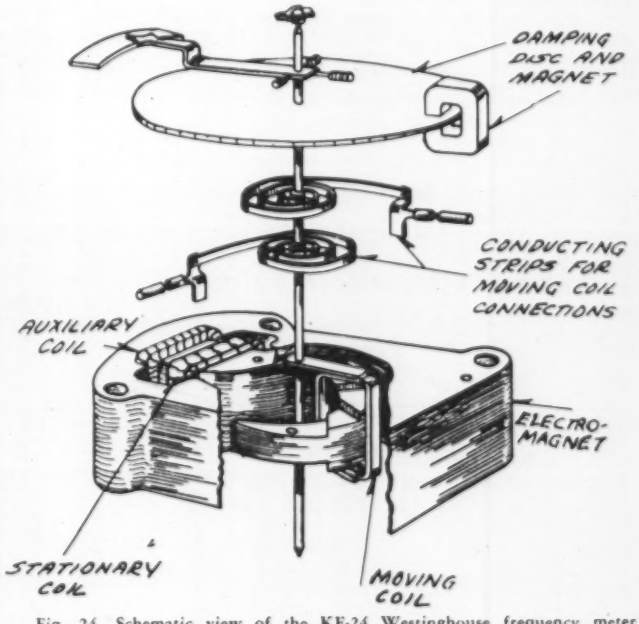

Fig. 24. Schematic view of the KF-24 Westinghouse frequency meter mechanism.

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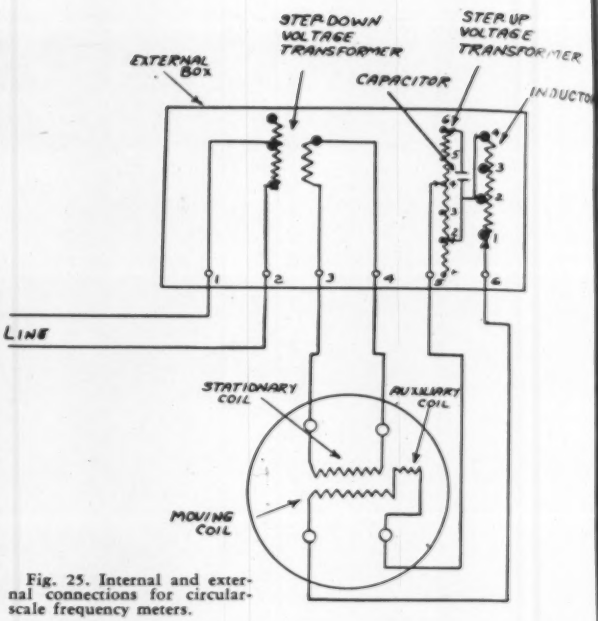

Fig. 25. Internal and external connections for circular-scale frequency meters.

ment of capacitor reactors feeds the stationary coils an that the moving coil and repulsion field coil are in serie with the network. As the field coils are wound in opposit directions, the field across the air gap will be depender upon the difference in current in the two coils. Each of th two branches of the split-phase circuit is resonated at different frequency, the scale range depending on differenc of frequency between the resonant point of each circuit From this it can be seen that the function of the movin system is dependent upon the flux due to the difference i currents in the two stationary coils and the flux due to th sum of these two currents that flows in the moving coi Since the coil of the repulsion element is in series with th rest of the circuit, the controlling torque is proportion to the total current in the circuit.

Test and Inspection

The test and inspection of a circular-scale frequenc meter follows the same pattern as that given the previou ly-described instrument of this type. The details diffe slightly; therefore only the variations will be explained other points will be mentioned merely as a means of out lining the operation sequence.

The mechanical inspection and adjustments are the sam as those given a wattmeter except for balance. The balanc of the frequency meter differs by reason of the absence

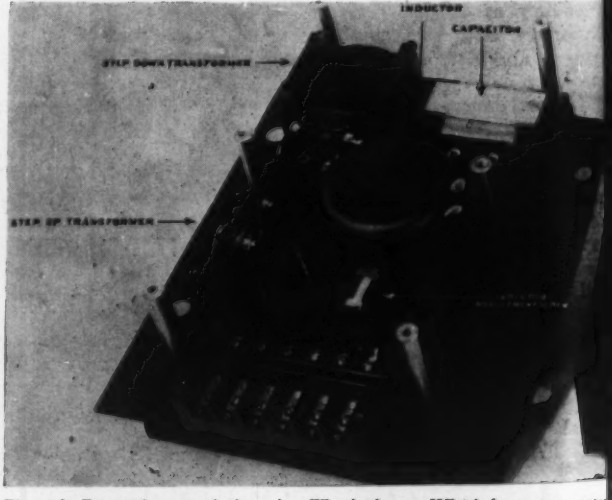

Fig. 26. External network box for Westinghouse KF-24 frequency mete

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a control spring. The only springs used in the assembly of the frequency meter are the so-called no-torque conducting springs. These springs do have a slight torque, however, hence the following method of balance: With the instrument face up, note the position or no-torque setting of the pointer. The instrument should then be set and adjusted (using the balance weights) so that the pointer tip comes to rest one sixteenth inch of the face-up no-torque setting of the pointer when the instrument is in the normal operating position and when rotated in stops of 90 degrees.

All calibration adjustments of the KF-24 frequency meter are made in the external reactor box. With the instrument connected as in Fig. 27, rated voltage at normal frequency

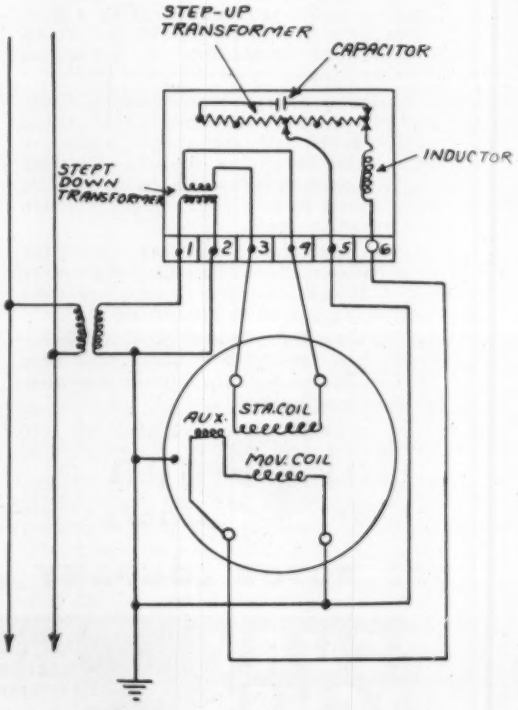

Fig. 27. Circular-scale frequency meter connections.

should be applied and an adjustment made to bring the pointer to mid-scale. With this connection, the pointer should be at approximately mid-scale when rated voltage is applied at 60 cycles. If the pointer indication is high or low, disconnect lead *1* of the inductor and connect lead *2* of the inductor to terminal *6*. If further adjustment is necessary for this approximate point, disconnect lead *3* and connect lead *4* of the inductor to the step-up transformer tap Number 1. The inductor leads should be changed around as above until the pointer comes to the approximate center of the scale. The exact center or normal frequency point can then be adjusted by manipulating the screw adjustment of the inductor. The end scale should next be checked and the scale length adjusted by interchanging tap connections on the step-up transformer shown in Fig. 27. If the scale length is too long, reduce the inductance and, if short, increase the inductance. For example, if the scale length is short when the Number 3 tap of the step-up transformer is connected to terminal Number 5, change the lead from tap Number 3 to tap Number 4 of the transformer. This change will increase the scale length approximately ten degrees. The scale length is limited to approximately 210 degrees because of the critical torque point at the high end of the scale. If the high end of the scale is beyond the critical point, it has a tendency to fall out of scale. The selection of new tap combinations of the step-up transformer may be necessary to keep the adjuster screw within limits. (The outer end of the screw should be between 1 to 1⅝" from the reactor shield). When tap combinations are changed, readjust the calibration screw for the center scale point.

In the AB-12 frequency meter, the calibration is affected

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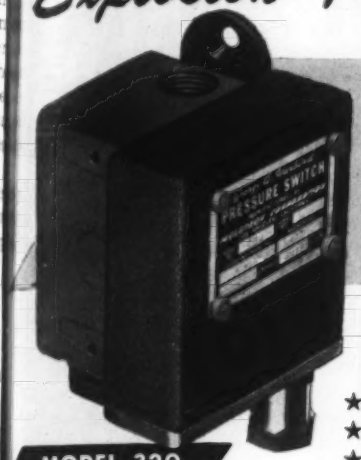

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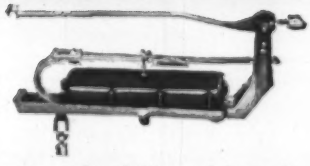

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by adjusting the capacitor-reactor networks in the external impedor. The networks as explained under principle of operation are adjusted so that at normal frequency (usually 60 cycles) the two networks are balanced. When this adjustment has been effected, the scale can be calibrated by using a standard of known accuracy. Slight shifting of calibration, either to the high or low side of the scale, can be corrected by changing the position of the restoring-element field-coil. The restoring element coil can be shifted by loosening the two field-coil clamp-screws and rotating the coil. Small adjustments of scale length can be corrected by increasing or decreasing the gap between the adjustable iron on the reactance coil and the coil itself. If greater scale length is desired, the reactance of the coil connected to terminal *A* should be increased and the reactance of the coil connected to terminal *D* should be decreased to correct for mid-scale point. To shorten the scale, the reactance of the coil connected to terminal *D* should be increased and the reactance of the coil connected to terminal *A* should be decreased to correct the mid-scale point. To increase the reactance, move the adjustable iron closer to the coil or change the taps on the coil winding.

Maintenance

Aside from the normal possible errors in this class of instrument, there are a few specific points to consider in the frequency meter.

Large deviations in voltage from the normal or calibrated voltage range may cause an error of frequency indication. Therefore, it is suggested that for best accuracy, the voltage should be held as close as possible to the calibrated voltage.

Change of balance affects the calibration of the frequency meter considerably; therefore, in working on an instrument, care should be exercised so as not to distort or bend any of the moving parts. Bends or displacement of conducting springs, coil distortion, bent pointers, shift of balance weights or loose end play are a few of the items that could affect balance.

If for some reason it is necessary to recalibrate a frequency meter, be sure to tighten the lock-nut on the adjusting screw of the inductor in the external box to prevent the screw from changing its position and hence affecting the calibration.

Other possible causes of errors such as friction, sticking, burnouts, short circuits, open circuits, etc., have been discussed in previous sections.

SHOP KINK

Electric Arc Welding *of* Thermocouples —Immersion Technique

By J. FELTON FURRH, Bishop, Texas

INSTRUMENT maintenance men not familiar with welding technique frequently run into trouble when they attempt to construct thermocouples in the shop. If the following method is used, anyone can get a clean, pure and permanent weld on any type of wire.

1. Fill a small glass beaker approximately two-thirds full of mercury (preferably triple-distilled).
2. Pour one inch of transformer or slide-wire immersion oil on top of the mercury.
3. Ground electric arc welder to mercury.
4. Secure both wires of thermocouple in electrode holder and dip twisted end into mercury. At the moment of contact the wires will be fused in a clean ball or "bead" weld.

The oil keeps the thermocouple from heating above the weld; and keeps air from coming in contact with the welding arc; therefore prevents oxidation.

"The Machine Age has not been free from evils, but the Age of Instruments is making Technology a pure blessing."

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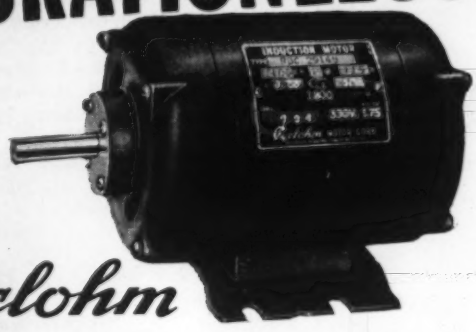

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Send for Catalog 93 which describes a number of other designs.

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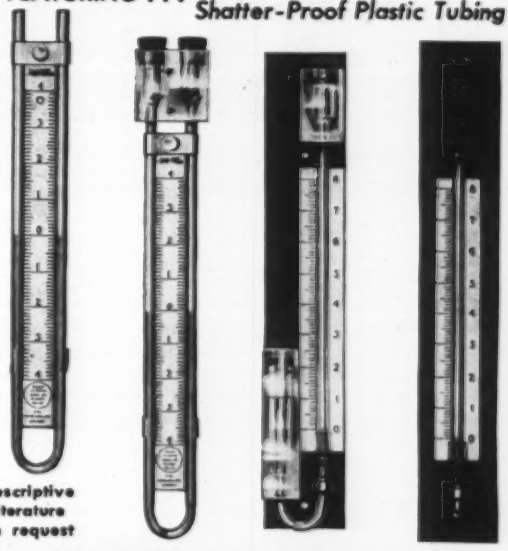

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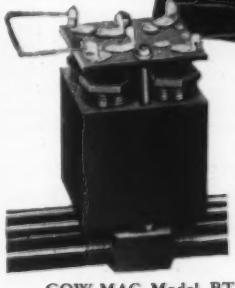

GOW-MAC Model BK, at left, with gas flow arranged for comparative analysis. Recommended for observation of hydrogen, helium and their mixtures. Straight bare wire filament, excellent zero stability.

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INSTRUMENTS ON THE MARCH

Altimeter Lag in Simulated Dives and Climbs

WASHINGTON, D. C. — Accurate pressure altitudes are often necessary during dives and climbs of aircraft, and other maneuvers in which the altitude changes rapidly. The sensitive altimeters used to make this measurement are ordinarily calibrated statically, that is, by holding constant the selected absolute pressure. A dynamic calibration, on the other hand, is one in which all readings are made instantaneously while the pressures are changing. This type of calibration is essential for accuracy under dynamic conditions of use, as exemplified by high speed dives or the rapid climb rates possible with jet planes.

Because the special apparatus and procedures required have not been available, the performance of the altimeter itself has been based on data obtained through indirect methods of analysis and has therefore been the subject of some speculation. This situation has been effectively clarified by an accurate dynamic method of calibration of altimeters developed by Dr. Daniel P. Johnson of the National Bureau of Standards under the sponsorship of the National Advisory Committee for Aeronautics. In connection with this work Dr. Johnson has determined the dynamic lag—the difference between the altimeter reading at a given pressure when calibrated statically and dynamically—for a number of sensitive aircraft altimeters and other aneroid barometers. Results of this investigation indicate that, from the standpoint of efficiency, production tests should be directed toward selecting instruments of relatively low lag rather than attempting detailed measurements of the lag in erratic instruments.

The method of determining the dynamic corrections near any given test point consists essentially in photographing, at definite short-time intervals, the readings of the altimeters under test and the liquid levels in a manometer which measures the difference between the rapidly-changing pressure to which altimeters are subjected and the substantially constant pressure maintained in a large ballast tank. Rates of climb or descent are determined from the time interval and the change of reading between successive observations. The absolute pressure in the ballast volume is obtained by readings on the standard mercurial barometer.

In the apparatus for dynamic calibration (see Fig. 1) the instruments under test are connected by a manifold to a ballast volume, to one leg of the check-valve manometer, and to the valve by which the rate of pressure change is controlled. The right leg of the check-valve manometer is connected to a second ballast volume, to the standard mercurial barometer, and to the valves for pressure control. The check-valve manometer, the instruments under test, a clock, and a thermometer, are grouped in the field of view of a camera and illuminated by stroboscopic lights.

In operation, the part of the system containing the mercurial barometer is maintained at a constant pressure, near which dynamic observations are desired. The instruments may be carried through the desired sequence of pressure changes without disturbing the set pressure. Photographs are taken at convenient time intervals when the pressure applied to the instruments comes within range of the set pressure plus or minus the indication of the check-valve manometer. This manometer is the U-tube type, fitted with hollow glass ball check valves which float on the normal butyl phthalate used as a manometer liquid to prevent liquid entering the lines during periods of overpressure. Corrections are made for its lag in indication.

The camera shutter is left open during a test run while stroboscopic lights for illuminating the instruments are flashed at equal time intervals controlled by a specially constructed relaxation oscillator. In this manner multiple images (Fig. 2) are secured on a single film, at pressures near the set point, while the pressure is changing.

According to Technical Report 123 of the NBS, data have been obtained under conditions that are equivalent to rates of change of pressure altitude up to 30,000 feet per minute. Measurements with the apparatus may be extended, however, to 50,000 feet per minute.

In order that all instruments will have comparable pressure exposure prior to test, they should be put into a "cyclic" state. For this particular investigation the instruments were subjected, while being constantly vibrated, to six cycles of pressure change covering the entire range of the test.

The dynamic lag manifests itself as an increase in the hysteresis; that is, the difference, at the same pressure in a pressure cycle, of the instrument readings for pressures increasing and decreasing. The increase is approx-

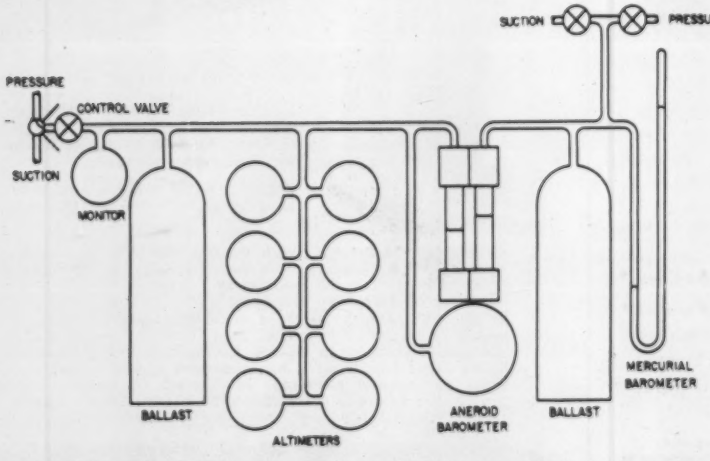

Fig. 1. Schematic diagram of apparatus used in a method developed at the NBS for the dynamic calibration of altimeters under conditions of rapidly-changing pressures simulating dives and climbs.

Fig. 2. Photographic observations in dynamic calibration of altimeters at a simulated rate of ascent of 30,000 feet per minute. Using stroboscopic lights flashed at equal time intervals, multiple images are secured while the pressure is changing.

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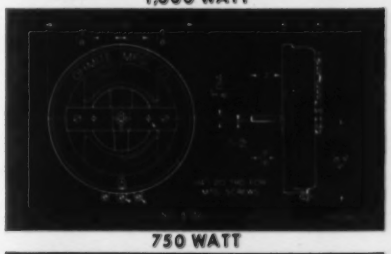
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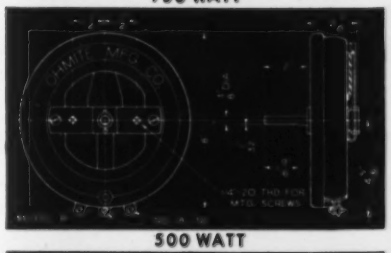
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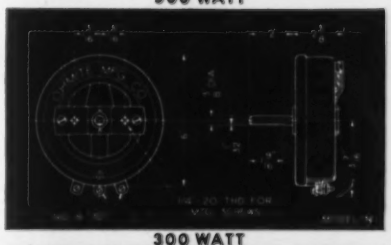
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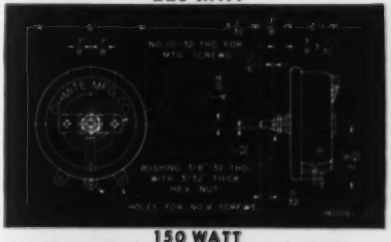
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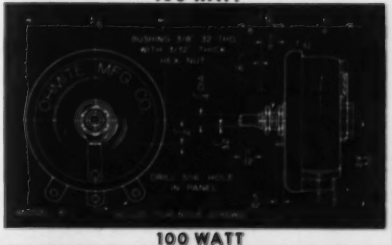
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How to Select a RHEOSTAT

1 UNIFORM WINDING

It's easy to choose the right uniformly wound rheostat if you have certain basic data. Knowing the *resistance* required and the *maximum current* for the circuit (circuit current with rheostat shorted out), the rheostat wattage can be calculated by the formula: $W=I^2R$. A standard rheostat, the wattage of which is not less than the calculated value, can then be selected from the Ohmite catalog. If the resistance and maximum current are not known, Ohmite engineers can calculate them from various circuit information you can supply about the application.

2 TAPERED WINDING

In a tapered winding rheostat the winding is made up of two to six sections of diminishing wire sizes. This construction allows a large resistance change to be "telescoped" into a small part of the winding, thus providing more uniform control and reducing over-all rheostat size.

The design of a tapered rheostat is not as simple as choosing a uniformly wound unit. Taper-wound rheostats can be selected from the standard designs listed in the Ohmite catalog for field control of generators, or Ohmite engineers will be glad to make specific recommendations.

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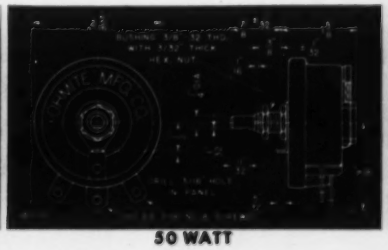
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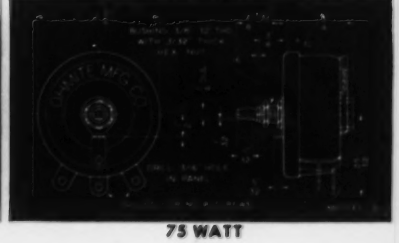
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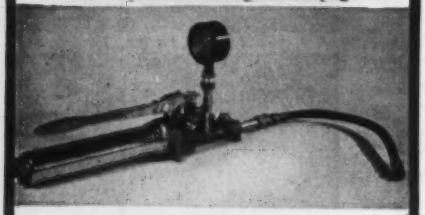
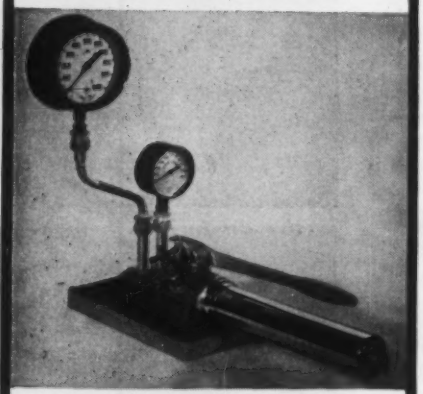


1 PORTABLE PRESSURE TESTING
Weight, filled with oil, 8½ lbs.



2 BENCH WORK WITH TEST GAGE
mounted on aluminum drip pan

3 DEAD WEIGHT TESTING
shown with dead weight attachment mounted on unit.
Write for Bulletin

MANSFIELD & GREEN
1051 Power Avenue CLEVELAND 14, O.

mately symmetrical, so that adding twice the dynamic lag to the static hysteresis gives the dynamic hysteresis. The dynamic lag is such that the altimeter reads high on descent and low on ascent.

The better 35,000-foot altimeters will probably have dynamic lags of about 5 to 10 feet at low rates (below 3000 feet per minute), and 20 to 30 feet at 30,000 feet per minute. The lags are somewhat greater and more erratic for 50,000-foot altimeters. Low lags were noted among the large-diameter aneroid barometers because there is relatively little friction. Large and irregular lags appear to be associated with large values of the pointer friction. This irregular and erratic lag for a given altimeter was found to vary with readings. As to accuracy, the dynamic calibrations compare favorably with the conventional static calibration and, at low lags, the dynamic method appears to be even more reliable.

Mass Spectrometer Applied to Metals Analysis

PITTSBURGH, PA. — Vaporizing metal samples in a small filament-type furnace has enabled Westinghouse physicist William M. Hickam to trace metal impurities by means of a mass spectrometer. Using two - milligram samples, the new method will detect as little as one part of the impurity per million. The equipment was devised for a special research project and is not commercially available.

The mass spectrometer has been used for years in the analysis of gases, but this is thought to be its first successful application to metals. Its use will permit completing in a few minutes an analytical job that would take days by chemical means.

The mass spectrometer consists essentially of an ionization chamber and a curved section with narrow slots

William M. Hickam, Westinghouse physicist, loads sample chamber preparatory to analyzing metal vapor by means of a mass spectrometer.

at each end. Ions of the vapor being analyzed are separated electromagnetically so that only those having certain atomic weights pass around the curve and through the exit slot. These are deposited on a plate just beyond the slot. Their quantity is determined by measuring the charge on the plate.

University of Pittsburgh's 1948-49 Program of Graduate Work in Industry

This year it requires a 48-page booklet to describe the University of Pittsburgh's program of graduate work in Industry for the fall semester (Sept. 20-Jan. 25) and spring semester (Feb. 10-June 4). A few of the courses of special interest to our readers:

Process Engineering Instrumentation. Theory and application of basic instrumentation control in chemical processes. The instrument mechanism will be considered during the fall semester. This will be followed by the application of the various types of commercial units to industrial practice. First and second semesters. Two credits each semester. Tuition $20 a semester. Thursdays, University Campus, 7:00 to 9:00 p.m.

Inspection and Quality Control in Manufacturing. Organization and functions of inspection and quality control departments in manufacturing activities. Practical applications of inspection, sampling, and control techniques. Control methods for raw materials, work in process, finished parts, and completed assemblies. Second semester only. Two credits, Tuition $20. University Campus.

Applied Spectroscopy. Spectrographic analysis of chemical, mineralogical, and/or biological samples. Laboratory work: fall semester, qualitative techniques; spring semester, quantitative techniques. Some absorption spectroscopy, spring semester. Prerequisites: first year courses in physics, chemistry, and mathematics; for graduate credit, Physics 31 and calculus. First and second semesters. Four credits each semester. Tuition $40 a semester. Mondays, University Campus, 6:20 to 11:00 p.m.

X-ray Diffraction Analysis. Atomic structure and x-ray spectra; diffraction of x-rays by crystals; powder. Laue and rotation crystal diffraction patterns and their interpretations. Crystal structure analysis of materials. Application of diffraction methods. Prerequisites: atomic physics and calculus. First semester only. Three credits. Tuition $30. Tuesdays, University Campus, 4:35 to 10:00 p.m.

Treatment of Experimental Data. Representation of data by tables, graphs, and equations; graphical differentiation and integration; precision indices and their propaga-

tion: adjustment of conditioned measurements; least square equations; correlation; Fourier series; search for periodicities; mechanical and electrical calculators. Prerequisites: 12 credits of physics and differential equations. First and second semesters. Three credits each semester. Tuition $30 a semester. Mondays and Wednesdays, University of Pittsburgh Campus, 6:45 to 8:00 p.m.

Servomechanisms. Course will emphasize principles of servomechanisms. Various components will be studied with regard to their characteristics. Simple "stabilizing" or "anti-hunt" means will be investigated and at least one complete servomechanism system will be designed. In this design the various methods available for calculating servomechanism performance will be discussed. Prerequisite: differential equations. Second semester. Two credits. Westinghouse registration. Westinghouse Educational Center, Tuesday, 7:00 to 9:00 p.m.

Instrumentation Short Course

The Agricultural and Mechanical College of Texas, at College Station, Texas, will offer its third short course on "Instrumentation for the Process Industries" on October 26, 27 and 28, 1948. The course will be conducted as a seminar with lectures and discussions on automatic control. Cooperating with Texas A & M will be many industrial concerns manufacturing oil, gas, and chemical products. Manufacturers of instruments and automatic controllers are taking part by arranging to show educational exhibits and provide capable lecturers for many of the sessions.

The lectures will cover measurement and control of temperature, pressure and liquid level, time control, and other allied subjects. The relationship between practice and basic control theory will be stressed. Problems of instrument maintenance will not be covered specifically in the lectures, but ample opportunity for the consideration of such problems will be provided in the discussion periods.

Anyone living either in or outside Texas is eligible to take this course on payment of the $5.00 registration fee; pre-registration by mail is encouraged. Rooming accommodations and meals will be available on the campus at the college dormitories and mess hall at a reasonable price. An evening banquet and entertainment are also planned.

Further information may be obtained by writing Professor P. G. Murdoch, Chemical Engineering Department, Texas A & M College, College Station, Texas.

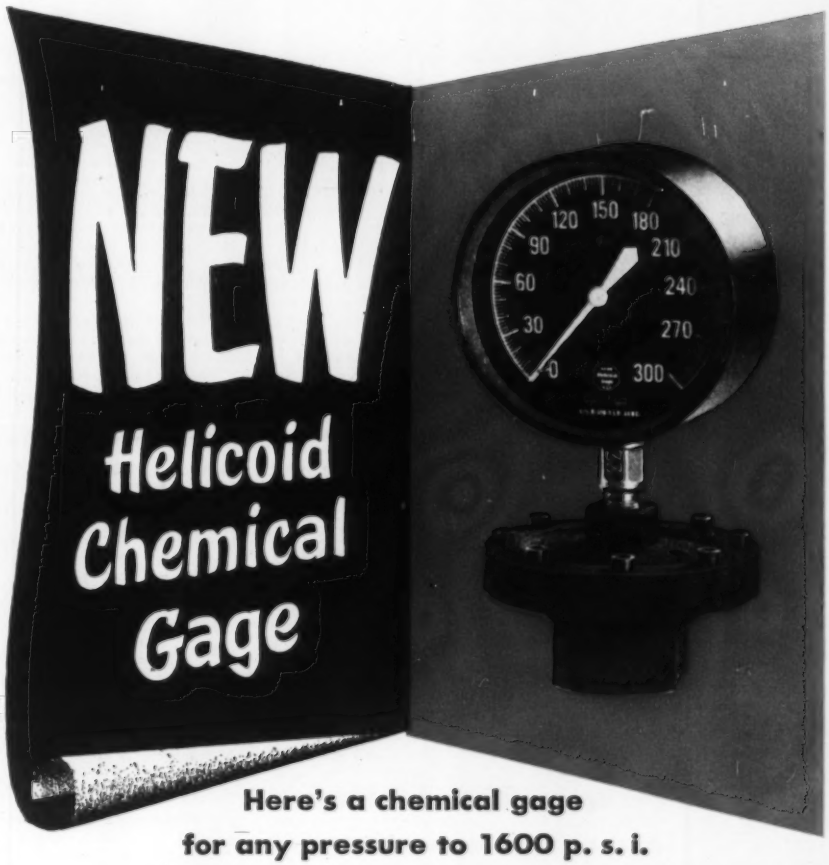
AIEE Fall Meeting

The 1948 Fall General Meeting of the American Institute of Electrical Engineers will be held at the Hotel Schroeder, Milwaukee, Wisconsin, October 18 to 22, inclusive. Numerous inspection trips and a full technical program have been planned.

ASQC

The eight midwest sections of the American Society for Quality Control are holding their Third Midwest Quality Control Conference at the Sherman Hotel, Chicago, November 4 and 5, 1948. The Conference is again being sponsored by the Chicago Association of Commerce.

Prof. Lloyd A. Knowler of the University of Iowa, Chairman of the Program Committee, has organized an excellent group of speakers for both the clinical and training sessions. Highlighting the Conference program will be the luncheon sessions, at which two top-ranking business executives will give down-to-



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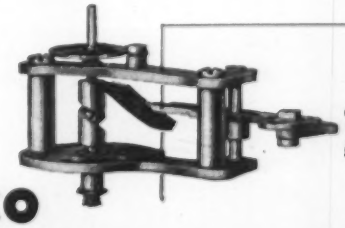

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earth talks on the benefits of statistical quality control applications in their plants.

On the first day, Col. Charles D. Wiman, President of Deere & Co., will be the luncheon speaker. The second luncheon meeting will feature Hugo A. Weissbrodt, Works Manager of International Harvester's Fort Wayne Motor Truck Division.

Under the general chairmanship of James M. Ballowe of Aldens, Inc., the full Planning Committee has been meeting regularly for a year, and a well-rounded program has evolved. In addition, the Conference will feature many exhibits, where the latest devices for measurement and control will be demonstrated.

The cost of the two-day meeting, including luncheons and sessions is $15.00. Further details may be obtained by writing to Third Midwest Quality Control Conference, P. O. Box 1097, Chicago, Illinois.

Pittsburgh Diffraction Conference

The sixth annual Pittsburgh Conference on X-Ray and Electron Diffraction will be held November 19 and 20 at Carnegie Institute of Technology, Pittsburgh. The conference is being sponsored this year by the local members of the American Society for X-Ray and Electron Diffraction (ASXRED) Carnegie Institute of Technology, the University of Pittsburgh, and the Mellon Institute of Industrial Research.

Technical papers will be presented in four sessions on Friday and Saturday mornings and afternoons. A dinner will be held on Friday evening, following which Sir Lawrence Bragg, director of the Cavendish Laboratory in Cambridge, England, will deliver the principal address of the Conference.

General chairman of the Conference is Professor Roman Smoluchowski of the Metal Research Laboratory, Carnegie Tech. Chairman of the Program Committee is Dr. Harold P. Klug, Mellon Institute.

Advance registration is requested: please send notice to Mr. C. W. Cline, Aluminum Research Laboratories, Box 772, New Kensington, Penna. The local committee further requests that out-of-town visitors make their own hotel reservations. Hotels Schenley and Webster Hall are most convenient to the scene of the meetings.

Society for Applied Spectroscopy

The meetings of the Society for Applied Spectroscopy will be held at the Lecture-Hall, Old World Building (Socony Vacuum Training Center) 61 Park Row, New York City, at 8:00 p.m. on the FIRST TUESDAY of each month:

October 5: Dr. Van Zandt Williams, "Developments in Infrared Absorption Spectrometry."

November 9: Dr. Lester W. Strock, Title to be announced.

December 7: Dr. Wallace A. Brode, "Ultraviolet Absorption Spectroscopy."

January 4: Speaker to be announced.

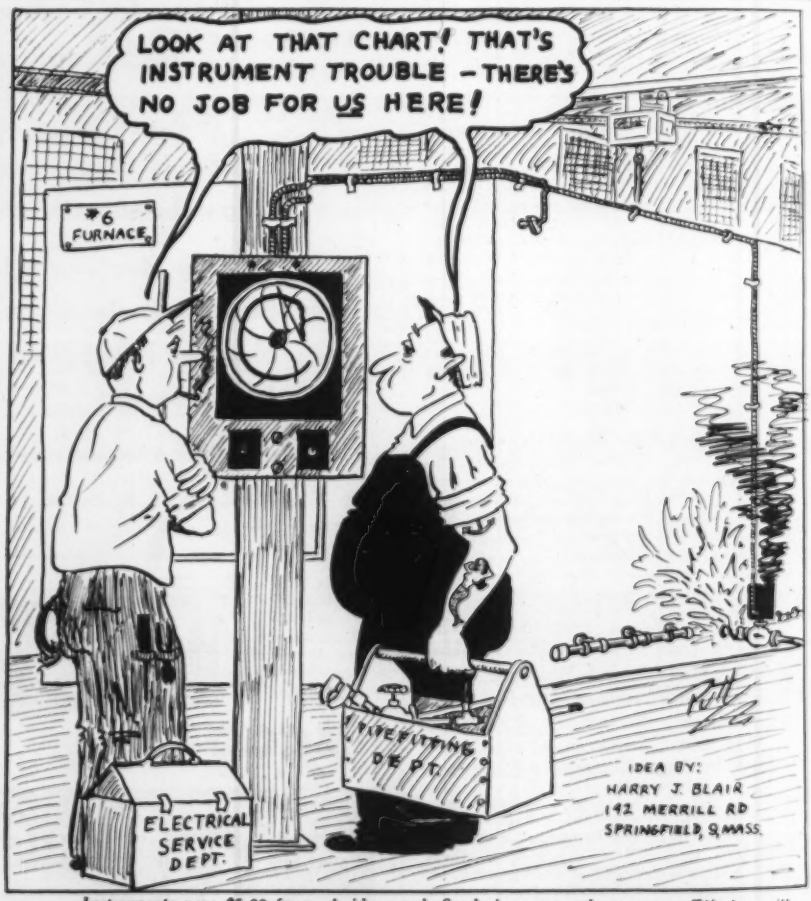
February 1: Dr. F. Nolan, "Fluorescence in the Field of Spectroscopy."

The Chairman of the Society for Applied Spectroscopy is Dr. E. K. Jaycox (Bell Telephone Laboratories, Murray Hill, N. J.), and the Secretary is Mr. R. R. Hampton (U. S. Rubber Co., Passaic, N. J.).

HENRY H. HAUSNER, Chairman
Public Relations Committee.

WHEN A FELLER NEEDS CONTROL

By Phil Putnam



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JOURNAL of the Instrument Society of America

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Section News

ARUBA

The 23rd regular meeting of the Aruba Section was held on Tuesday, August 3, 1948. The business of the evening included the announcement of replacements for Officers who are leaving on home furlough prior to the next meeting:

Mr. N. P. Schindeler for Mr. J. L. Lopez
—*President*

Mr. M. R. Holly for Mr. S. C. Chapman
—*RPC Chairman*

and for Mr. L. L McGrew
—*Journal Correspondent*

The rest of the business was disposed of quickly so that we could enjoy three films loaned us by Brown Instrument Company. These films, titled "Basic Electricity, Basic Electronics and Autopilot," were definitely on the elementary side but proved very interesting and informative. The films were produced by Disney studios and used his famous animated figures for illustrating volts, amps., and resistance.

The first film covered the fundamental principle of Ohm's Law by illustrating in several circuits showing (with animated figures) that the summation of IR drops equals the applied voltage. The principle of the transformer was also included to show how the E is increased by induction.

The second film started with a simple battery and explained the Bohr atom theory and applied it to the vacuum tube. Emphasis was placed on the use of the vacuum tube as an amplifier which was later to be used with servomechanism in the automatic pilot as used in airplanes.

The third film applied the material covered by the first two to the operation of servo-mechanisms. As a plane leaves its normal flying position, contact fingers on rheostat mounted on a gyroscope assume a new position and cause an unbalanced condition in a bridge circuit.

This unbalance is amplified with vacuum tubes to operate the controls of the plane to bring it back to its normal flying position. The steps necessary to achieve this end are aptly illustrated and easily understood. Although these films deal with servo-mechanisms used in planes, it is easy to apply the same functions to other applications.
—M. R. HOLLY, *Sec'y.*

NEW JERSEY

Section Plans Dinner Dance

Wm. Archibald of Energy Control Company has been appointed Chairman of a Committee to make arrangements for the first social function planned by the Jersey Section. His committee has met and plans have been formulated for a gala event. The date will be Wednesday, November 10, Armistice Eve. The place, the Oxford Room of the Essex House in Newark. Marty Ames and his Essex House Orchestra will play for dancing.

The party will start with a reception at 7 o'clock and cocktails will be available at bar adjoining the Dining Room. Dinner will be served at 7:30 and the Orchestra will play for dancing during dinner and until midnight. Dress will be informal and tariff will be $4.75 per person.

The committee includes Harold McCarthy of Standard Oil Development Company and George Feeley of Trinity Equipment Company. The committee is relying on the support of the members and their friends to make this the first of a series of successful affairs.

OAK RIDGE

On August 4th, the Oak Ridge Section held its 28th meeting at Ridge Hall. Guest speaker for the evening was Dr. John Trimmer, Professor of Physics at the University of Tennessee where he teaches subjects related to instrumentation and servomechanism. His subject: "General Feedback Problems in Relation to Accurate Control Systems."

Basic concepts and elementary principles were first explained. Using certain mechanical illustrations, the discussion led toward an exposition of the problems confronted by a design engineer without, however, going into complete analysis of involved electronic and mechanical systems.

Dr. Trimmer is well known in Oak Ridge for his work in electrical development at the Y-12 plant where he was employed from 1943 to 1947. Following this assignment and before going to the faculty of the University of Tennessee he assisted with the development of a control system for the high flux reactor at Oak Ridge National Laboratories. His experience before coming to Oak Ridge was divided between teaching and instrument engineering for industry.
—J. O. ALEXANDER, *Sec'y.*

NIAGARA FRONTIER

Twenty-two members attended the informal meeting on the evening of July 12, at the Edgewater Park Hotel on Grand Island. President Clarence Boltz was very pleased by the number of members present, as this was the first dinner meeting held by this Section. Following dinner there was a brief, but exciting softball game. First Vice President, Joseph Hildyard, distinguished himself by hitting 3 home runs.

A short meeting was then held, very informally, out on a small dock projecting into the Niagara River. Plans were discussed for attending the September convention in Philadelphia.—W. J. SOMMERS, *Corr.*

Errata

In the report of the Tulsa Section which appeared in the JOURNAL for June 1948, the Executive Committee member elected for two years should have read, "Mr. R. P. Walker, Brown Instrument Div., Minneapolis-Honeywell Regulator Co."

I. S. A. EMPLOYMENT SERVICE

Forward your letter to INSTRUMENT SOCIETY OF AMERICA, 1117 Wolfendale St., Pittsburgh 12, Pa.

ELECTRICAL INSTRUMENT ENGINEER with experience in design, development and manufacture of watthour meters, induction relays, graphic instruments, etc. Age no barrier. Must be familiar with application of instruments to industrial switchgear. Degree not essential if background shows adequate practical experience. Excellent opportunity offered for advancement based upon extensive development program. Location Eastern Pennsylvania. Box 156.

. . .

SALES ENGINEER experienced in the application of tension measuring and controlling devices particularly in the textile industry by leading manufacturer in this line. Location New England. Box 157.

. . .

SALES MANAGER with executive ability capable of planning, initiating and carrying through a complete sales program with budgetary limitations which would include publicity, advertising, direct mail campaigns and proper handling of correspondence. Should be able to direct activities of sales force, procure and direct activities of national representatives and be familiar with Government contract operations. Location California. Box 158.

INSTRUMENT MECHANIC for instrument repair at Milwaukee, Wis. plant. Duties consist of maintaining instruments such as temperature and pressure recorder-controllers, recording thermometers; pressure gauges; etc. Box 159.

. . .

INSTRUMENT DESIGN ENGINEER for development of instruments in connection with radar as applied to meteorology and basic studies of associated phenomena. Would be responsible for the calibration and maintenance of certain instruments already developed. There would be an opportunity of taking a course of study at the Massachusetts Institute of Technology as a special student. Location Cambridge, Mass. Box 160.

. . .

INSTRUMENT APPLICATION ENGINEERS. Graduate with B. S. in Engineering or Physics. One to two years experience with industrial recording instruments (preferably electronics), gages and controllers. Three engineers required. Location Oak Ridge, Tenn. Box 161.

. . .

ELECTRONIC ENGINEERS. B. S. in Electrical Engineering or Physics with some experience in electronic circuit design work. Should be familiar with wide band amplifiers and pulse techniques. Five engineers required. Location Oak Ridge, Tenn. Box 162.

(Continued on page 864)

A Functional Library Organization for Instrumentation Research

By CHARLES A. MABEY*

THE organization of technical work in modern industry, particularly that in which research and development activities are involved, inevitably raises problems of providing library and other informational services for its personnel. To say "inevitably" may seem to some to overemphasize the importance of the problem, but as the war has given a new impetus to technical research and development activities in large industries and small, it has also resulted in a new awareness of the conditions under which this kind of work can be carried on most fruitfully. Creative activity—which, after all, is the prime objective in this work—feeds on the vast store of accumulated knowledge as it is recorded in books, periodicals and the many other sources of published information. "The more extensive a man's knowledge of what has been done, the greater will be his power of knowing what to do." The importance of this was illustrated some years ago by an officer of one of the very well-known industrial research laboratories in this country speaking in a symposium on research methods. As one of the few "text-books" in his opinion on the subject of research, he cited a book called *The Road to Xanadu*, by Professor J. L. Lowes of Harvard. Probably few in that audience of chemists and chemical engineers realized that Professor Lowes was a professor of English Literature and his subject in that delightfully written book was a study of the effect of voracious reading on the creative activity of the poet, Samuel Taylor Coleridge, which found expression, particularly, in that classic, *The Ancient Mariner*. In science no less than in poetry this creative energy of the mind responds to the stimulus of wide reading in the work and ideas of others.

Furthermore, as a purely practical matter, there are common to all technical organizations such problems as those of providing for the storing of the experience and information acquired by its own staff in the form of reports, memoranda, etc.; problems, also, of keeping up with the state of the technical art through periodicals, patents and trade literature; and the problem of keeping readily at hand handbooks of fundamental principles and compiled technical data needed for constant reference, as well as information such as the advertising literature of the manufacturers who supply raw materials and components used in the company's products. The keeping of this sort of thing may, as this paper proposes, be assigned to a single responsibility in the organization, or left to the individual effort and system of each engineer, but one way or the other, I believe the elements of the problem are always there.

In most large, well-established companies, the expense of maintaining an adequate library and a staff of competent, specially trained personnel for it can easily be justified. In the smaller and newer enterprises, the question of providing any such facilities usually meets objections involving economy in expenditures, personnel and space. Yet this problem in the small organization is no less urgent and important. Indeed, it is likely that the small one can much less afford to ignore means such as this for effectively extending its physical limitations by making maximum use of work done or in progress as reported in the publications of one sort or another. Duplication of work already done in one laboratory, for example, is apt to represent much more of an economic loss to the small organization than to a large one.

The facilities to be described in this paper result from such considerations in a small engineering research and development organization. The description is offered as an example of a service which has been provided with due consideration for economy of maintenance, maximum utilization of facilities already available, and maximum attention to the specific needs of the organization it serves. While not designed by a professional librarian, and undoubtedly in many details the worse for lack of such professional assistance, it is thought, nevertheless, to meet most of the demands made upon it. The writer gratefully acknowledges having borrowed freely of the ideas of other libraries too numerous to identify individually. Much credit should also be given to the Special Libraries Association for the helpfulness of their members and services.

Since this paper will emphasize the organization of a service to meet specific needs, it will be necessary to describe briefly the company with which the present writer is concerned.

This company is devoted to the development and manufacture of measuring and automatic control apparatus for industrial processes. In a sense its business is the translation of the devices and techniques of the research laboratories of fundamental and applied science into industrial practice. It is, therefore, heavily dependent on maintaining contact with the work going on in industrial and academic laboratories throughout the country and, also, with changing requirements of a wide variety of industries in the use of measuring and control equipment. Such contacts are most effectively maintained through the published technical literature. As in many small companies, the acquiring of technical information needed for its operations was, formerly, left to the efforts of individual engineers. Eventually, the inefficiency, duplication of effort and general ineffectiveness of this system was realized, and the integration of informational facilities to be described was gradually evolved.

Fundamentally, the guiding principles of this service have been:

(1) to consolidate all responsibility for the keeping, procurement and dispersal of all publications needed by the technical departments of the company;

(2) to take maximum advantage of publicly available library facilities;

(3) to collect only such books, periodicals, and other publications as seem most needed for immediate and reasonably constant reference;

(4) to provide means for tracing sources of information, whether in our own library or elsewhere, on any required subject with reasonable ease.

First of all, in evaluating our problem, we found ourselves possessed of the following materials to form the basis of an informational service:

(1) Reference and textbooks on a wide variety of subjects,

(2) Periodicals, including current and old files of society publications, trade and industrial magazines covering a variety of interests,

(3) Miscellaneous reprints of papers, pamphlets, clippings, photostats and microfilms,

(4) Trade catalogs and manufacturer's bulletins,

(5) Patent copies and patent gazettes.

The problem was to collect this mass of material, to systematize it and to make it readily available; also to keep up somehow with the constant increase in this material and to obtain access to the fund of information available in the large libraries for use when needed —all this service at a reasonable cost of operation.

The library described here represents a gradual growth over about eight years and, for most of this time, it could not be permitted to occupy the full time of any personnel. It has, nevertheless, slowly justified more and more time being allocated to its maintenance, the expansion of its cataloging system, improvements in physical facilities such as steel shelving, and more adequate housing.

Considering now the various classes of materials noted above, it may be of interest to describe the disposition made of each of these in some detail:

I—Books

As a first principle, it was decided to limit the size of the book collection by the following general rules:

(a) To concentrate our purchases to our own field of specialization, namely, measuring instruments and techniques, and automatic control;

*Formerly Director of Research, Bristol Company, Waterbury, Conn., now with Electronics Division, National Bureau of Standards, Washington, D. C.

(b) To provide a generous collection of standard technical handbooks and tables for mathematics, physics, chemistry and engineering for ready reference;

(c) To avoid purchases of other books until frequent and general use justified, meanwhile borrowing from public libraries or other sources available to us as they were needed for temporary reference.

Hence, our collection of books is small, under a thousand volumes. It was, however, desirable to assemble these in an orderly way with particular reference to easy accessibility. On investigation, it was concluded that none of the standard classification systems, such as the Library of Congress or the Dewey Decimal system, were applicable to such a small collection with sufficient simplicity and flexibility to suit the specific needs of the case. We have, therefore, preferred to group this collection on the shelves according to the following system:

A—Reference Books — including dictionaries, encyclopedias, handbooks of all kinds, society and industrial directories, etc.

B—Business Administration — including patent law, management, accounting, sales.

C—Instruments and Automatic Control —divided into logical classes of this special field.

D—Mathematics.

E—Physics.

F—Chemistry and Chemical Engineering.

G—Metallurgy.

H—Engineering Materials (other than metals, (i.e. plastics, wood, paints, etc.).

I—Mechanical Engineering.

J—Electrical Engineering and Electronics.

K—Industrial Processes.

Each of these classes is subdivided into subject groupings and serial numbers are added for individual identification of each item on the shelves. For example, the first section is subdivided thus:

A—Reference Books

A1—Technical tables and engineering handbooks.

A2—Dictionaries — general, technical and foreign language.

A3—Directories—*Who's Who in Engineering*, Society rosters, industrial directories.

A4—Miscellaneous reference books—economic data, statistics, etc.

The aim has been to bring this group of books together so that they can be placed in a location that is most easily accessible, since, presumably, they will be most frequently used.

For an index to the book collection, a card catalog is provided, adequately cross-indexed, using Library of Congress cards where they were available and our own typed cards where they were not. Also, a shelf list of all holdings is maintained by the librarian as a master file of everything on the shelves and a record of all assigned serial numbers. For borrowers, a card is provided in each book in the usual way for signing out when it is taken from the library.

II—Magazines

As in all technical organizations, a great number of magazines of varied interest and usefulness are received in the company as a result of individual subscriptions, company advertising and affiliations. These, together with an inherited store of old magazines and journals, we have separated into four groups:

(1) Those valuable for permanent reference because of their direct bearing on instrumentation. These are maintained in complete sets and are bound in annual volumes;

(2) Those valuable for permanent reference, as journals of some of the learned societies, for which, in general, complete files have been collected for a period of fifteen to twenty years. These are not bound but kept in flexible, cardboard file boxes for cleanliness and protection from wear;

(3) A list of periodicals of semi-permanent interest, files of which are maintained in file boxes for convenience, for a period of five years;

(4) A group of publications of transient interest, mostly trade publications, which are discarded after one year.

The indexing of books is an easy matter compared to the task of indexing this mass of periodical literature. Obviously, too, our small collection does not begin to represent the wide range of subjects in which the technical staff may be interested. We would be fortunate indeed if it could account for even a small part of the demands most likely to be made on the material we have immediately available. Fortunately, however, means are available for searching out and obtaining access to almost any printed article wherever it may be found. We consider, therefore, the most important facility of our library to be the section containing published indexes and abstracting services. Of these, the most useful for our purpose are the *Engineering Index*, *Industrial Arts Index*, *Chemical Abstracts* and *Science Abstracts*. Lesser indexes in the form of bibliographies on specialized subjects should also be included with these. In general, of course, a small library must necessarily rely heavily on such professional guides to the published technical literature of the world.

To these, then, we refer a user of our library as a means of first resort in tracing published information on any given subject. When articles of interest are found, we may first check if the publication is in our file by reference to the general card file, the so-called "dictionary" file. If it is not found here, the item or items may be ordered from one of the other libraries in the vicinity as a loan, a photostat or a microfilm copy. In copying references of any considerable length, microfilm is usually preferred because of its lower cost, but in some cases, it is not convenient or desirable and photostat copies are then made.

III—Reprints, Pamphlets, Clippings, Photostats and Microfilms.

As a result of our policies, we are, of course, bound to accumulate a collection of copies of single articles in the form of reprints of published papers, pamphlets from governmental and other sources, clippings of articles taken from discarded magazines, photostats and microfilm copies purchased from the large libraries. With the exception of microfilms, which, obviously, require separate treatment, no special indexing of these is attempted. These are included in the published indexing services in which they may be found by subject, author or other method of approach. Our problem is, then, only to file these by a convenient system for future reference. Assuming that complete reference data is furnished by the index used, we have chosen to file these in vertical file drawers in which a folder or folders are provided for each magazine or source. In this way, anyone seeking a particular reference found from indexes or other literature, can readily check whether or not it is available in this reprint collection by examining this file after first ascertaining that we do not have a file of the journal itself.

The use of microfilm is increasing rapidly as a means for obtaining copies for reference of published material not readily available in the original. The use of film is preferred to photostats wherever possible because of economy in expense and also in filing space. It does, however, require separate treatment in filing since we tend to accumulate a lot of short lengths of film devoted to individual articles. It has seemed to suit our purposes, therefore, to adopt a system similar to that for books, that is, films are roughly classified by subject using the same system as outlined above for books. For each of the classifications, a one hundred foot reel is provided ready for use in the reading projector, and the films associated with that classification are spliced together on this reel. Serial numbers locate the position of the film on the reel and a record of numbers and titles are kept in a card file. A reading machine is, of course, available for use in reading film.

IV—Trade Catalogs

Every incoming mail brings to any engineering office its considerable bulk of catalogs and advertising matter, some of it asked for, most of it gratuitous. A good deal of this material has value and hence a problem arises in making information on industrial products and their suppliers readily available, maintaining a file with minimum effort and keeping it adequate and up-to-date. Catalogs and leaflets are filed alphabetically by manufacturer's name on open shelves. Unbound catalog material is placed in specially-made 9½" x 12" manila envelopes with the company name on the outside.

In using this file, it is visualized that an engineer will come to it either with the name of a manufacturer or with some product on which he wants manufacturer's data. In the first case he is referred, first, to a *Wheeldex* visible card file which lists all the manufacturers' names for which catalogs are in our file and, if he finds it listed, he will find a catalog on the shelves. In the second case, he is referred, first, to the *Thomas Register*, which lists companies by their products, then to the *Wheeldex* list, and, if available, on to the catalog shelves. The *Register* serves in this way as our only product index.